FEDERAL TRADE COMMISSION
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EXHIBITS ANNEXED TO

COMMENTS OF

BROWN & WILLIAMSON TOBACCO CORPORATION

ON THE

FEDERAL TRADE COMMISSION'S

PROPOSAL TO MODIFY THE

OFFICIAL CIGARETTE TESTING METHODOLOGY

(49 Federal Register 23120)

VOLUME II

EXHIBITS K-N

Brown & Williamson Tobacco Corporation
Louisville, Kentucky
July 5, 1984

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Exhibit K

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IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

FEDERAL TRADE COMMISSION, Plaintiff, v. BROWN & WILLIAMSON TOBACCO CORPORATION, Defendant.	Civil Action No. 83-1940 AFFIDAVIT OF ROGER D. KAMM

COMMONWEALTH OF MASSACHUSETTS)
: ss.:
COUNTY OF MIDDLESEX)

ROGER D. KAMM, being sworn, states:

1. I am an associate professor of Mechanical Engineering at the Massachusetts Institute of Technology ("M.I.T.") in Cambridge, Massachusetts, a position I have held since July, 1981. I teach courses in fluid mechanics, thermal sciences and heat transfer to undergraduate and graduate students at M.I.T. In addition to my teaching responsibilities, I have been engaged, in recent years, in research in the areas of biomedical fluid mechanics, fluid mechanics, and mass transport. I received my training at M.I.T. (Ph.D., Mechanical Engineering, 1977; S.M., Mechanical Engineering, 1973) and Northwestern University

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(B.S., Mechanical Engineering, 1972). A copy of my curriculum vitae is annexed to this affidavit as Exhibit A.

2. I was engaged as a consultant by the Brown & Williamson Tobacco Corporation ("Brown & Williamson") in 1981. Brown & Williamson markets a cigarette under the name "Barclay", using a unique filter design in which air drawn through perforations in the filter tip travels through four channels along the edge of the filter to the smoker's mouth. The resulting "dilution" or "ventilation" of the tobacco smoke causes a reduced delivery of "tar" and nicotine to the smoker.

3. The Federal Trade Commission ("FTC") has been concerned with charges, raised by the R.J. Reynolds Tobacco Company, Inc. ("Reynolds") and Philip Morris, Inc. ("Philip Morris"), competitors of Brown & Williamson, that Barclay is not appropriately rated as a 1 mg. tar, .2 mg. nicotine cigarette. R.J. Reynolds initially propounded a theory that Barclay smokers crush the Barclay's ventilation channels with their lips. Philip Morris' theory has been that Barclay smokers block the ventilation channels by draping their lips over the tip of the cigarette. My consulting work for Brown & Williamson has therefore been concerned with determining whether smokers actually crush the Barclay's ventilation

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channels with their lips or block the vents at the filter tip and, if so, what impact this has on cigarette ventilation and delivery.

4. My primary work for Brown & Williamson falls into two categories. First, in 1981, I conducted a series of tests intended to establish the range of pressures exerted by human lips on a cigarette filter tip during normal smoking. Because R.J. Reynolds had proposed that the FTC use the Filtrona cigarette holder in its cigarette testing program, these tests also sought to determine the range of pressures exerted by the Filtrona and other holders used in machine testing of cigarettes. These tests showed: (1) that the average pressure exerted by human lips in normal smoking is about 34 torr, far below the level of pressure which would be required to collapse the channels of the Barclay Actron filter; and (2) that of the three holders tested, only the Cambridge filter holder historically used by the FTC in its cigarette testing program approximates the average lip pressure found in human smoking. (Torr are units of measurements commonly used to quantify pressure. One torr is equal to 1.316×10^{-3} atmosphere.) These tests are described more fully in paragraphs 7-14, <u>infra</u>.

5. In the second series of tests, beginning in June 1983, I designed an experimental apparatus for use by

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Brown & Williamson scientists in tests intended to show how the ventilation achieved by the Barclay filter is affected by incremental increases in pressure on the filter tip, combined with changes in the depth to which the filter is inserted in the mouth. The data resulting from these tests show that cigarette ventilation does decrease with higher levels of lip pressure and decreasing insertion depth. At lip pressure well above the human average of 34 torr, with maximum simulated lip drape and minimum insertion depth, the tar and nicotine levels of Barclay smoke remain at or near the levels predicted by the cigarette's historical "rating" by the FTC method (1 mg. tar, .2 mg. nicotine). In these tests, simulated lip pressures much higher than any individual average found in human smoking were required to obtain tar levels approaching those which Brown & Williamson's competitors claim Barclay delivers. These tests are described more fully in paragraphs 15-24, infra.

6. To the best of my knowledge, the tests described above are the only scientific work ever performed to establish the extent of human lip pressure on filter cigarettes and the effects of such lip pressure, together with variations in insertion depth, on cigarette ventilation and tar and nicotine delivery. This work has shown that, by applying pressure well over the average human lip pressure

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and using a minimum insertion depth, the ventilation achieved by Barclay cigarettes is not impaired sufficiently to deliver "tar" and nicotine levels significantly higher than the 1 mg. "tar," .2 mg. nicotine levels at which Brown & Williamson rates Barclay.

A. The Lip Pressure Studies

7. My initial lip pressure studies were conducted in , 1981. As noted above, the objective of the tests was to determine: (1) the pressure exerted on the surface of a cigarette filter tip by human lips during normal smoking; and (2) the pressure exerted by three types of cigarette holders used in machine testing of cigarettes. The three holders included the Cambridge holder, used in the FTC's cigarette testing program, and the Borgwaldt and Filtrona holders. The Filtrona holder was propounded by R. J. Reynolds, for use by the FTC in testing of Barclay cigarettes.

8. I developed a special measurement system to measure the pressures applied by the human lip to the surface of a cigarette filter. A latex bulb, one to two millimeters in diameter, was mounted directly on the filter of each test cigarette and attached to a low compliance pressure transducer with a short section of hypodermic needle tubing and a

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teflon catheter. The entire system was filled with water to avoid the effects of air compression. A calibration procedure was also performed on each test cigarette to standardize the measurements obtained throughout the test.

9. Thirty-one human subjects, tested individually, were used in this study. The subjects were directed to smoke the test cigarettes normally, with the pressure sensing bulbs centered on the lip. Both Barclay cigarettes and Rich Lights were used in these tests.

10. For each puff, the pressure changes were observed on an oscilloscope screen and the peak pressure attained during each puff was recorded. Three average pressures were computed for each subject: an upper lip average, a lower lip average, and an overall average.

11. Results of the human lip pressure measurements showed that human lips exert an average pressure of about 34 torr. The range of recorded pressures was from 2.7 to an extreme of 133 torr.

12. We next measured filter holder pressure on the Cambridge, Borgwaldt, and Filtrona holders by inserting test cigarettes in the holders, adjusting the position within the holder until the maximum reading was achieved, recording all resulting measurements, and determining an average reading for each of the three filter holders.

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13. Each of the three filter holders was found to exert greater pressure than the average human lip pressure of 34 torr, as follows: Cambridge, 1.4 times as large as the average lip pressure; Borgwaldt, 3.5 times as large; and Filtrona, nearly 15 times as large.

14. The test methodology, apparatus, and results are more fully described in a report I rendered to Brown & in 1981. A copy is annexed to this affidavit as Exhibit B.

B. The Lip Pressure/Insertion Depth Studies

15. My initial studies did not control for variations in the depth to which the test cigarettes were inserted in the subjects' mouths. Insertion depth is, however, believed to be a critical factor in ventilation studies. It is only at the relatively shallow insertion depths that it becomes likely that the phenomenon known as "lip drape" -- the blocking of portions of the filter tip at its very end by the lips -- will occur. As noted above, Brown & Williamson's competitor Philip Morris has been the principal proponent of the theory that "lip drape" occurs in human smoking of Barclay cigarettes, causing occlusion (blockage) of the cigarette's ventilation channels at the very end of the filter tip.

16. Accordingly, on June 25, 1983, I prepared a design, for submission to Brown & Williamson, of a mechanical

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device which could reproduce the conditions which have been claimed to impair ventilation in real smokers. A copy of the written proposal I submitted is annexed to this affidavit as Exhibit C. The results of these tests strongly suggest that the data generated in R. J. Reynolds' and Philip Morris' dilution studies were biased against Barclay.

17. As of this date, the lip pressure and insertion depth tests have been performed with a smoking machine. The tests were performed in Brown & Williamson's laboratories in August, 1983, by Brown & Williamson scientists who consulted with me to develop and refine their test procedures and methodology. I designed the test apparatus, referred to herein as the "Kamm holder," which was used to simulate human lip pressure for purposes of these tests. A sample of the Kamm holder is being submitted with this affidavit as Exhibit D. On August 16, 1983, I visited Brown & Williamson's laboratories in Louisville, Kentucky. At that time, I was able to examine the test apparatus and to review the test methodology. I have also reviewed the report which was prepared by James F. Nall, the head of Brown & Williamson's testing laboratory, analyzing the test results ("the Nall Report"). The Nall Report reflects that these tests were performed substantially in accordance with procedures which I agreed upon with Brown & Williamson's scientists, and I am confident of the accuracy of

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the results obtained and the correctness of the conclusions reached. Indeed, my only reservation about these test data is that the tar values determined in the smoking tests appear to me to be higher than normal, based on the ventilation rates established in the ventilation tests. In other words, I suspect that the tar deliveries may have been exaggerated, for reasons which are not clear to me. A copy of the Nall Report is annexed to this affidavit as Exhibit E.

18. The test methodology was relatively simple. As noted above, we were interested in assessing the impact of variations in lip pressure and insertion depth on ventilation. Accordingly, Barclay cigarettes were tested in a ventilation test (unlit) followed by a smoking test (lit) at various different pressures and at varying insertion lengths, i.e., with decreasing lengths of the filter tip inserted in the holder. The pressures and insertion depths used in the test were based on the best information available about human smoking behavior. The Kamm holder is fitted with a silicone rubber tubing, which, when pressurized, is designed to mimic as closely as possible the pressure of human lips. The modulus of the tubing determines its compliance or stretchiness. A low modulus tubing, the thinnest walled, most compliant tubing available, was chosen for these tests to simulate the most possible "lip drape." A medium modulus

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tubing was also tested to give a basis for comparison. The test cigarettes were tested over a range of pressures and insertion depths in holders of the two different moduli, low and medium, in the ventilation and smoking tests. The orientation of the test cigarettes, and of the Barclay's four ventilation grooves, in the test holders was random, so as to replicate normal human smoking.

19. The basic test apparatus consisted of:

(a) a Kamm holder, specially designed to replicate human lip pressure when inflated;

(b) an apparatus for inflating the Kamm holder to apply pressure on the test cigarettes;

(c) a Gelman holder;

(d) a device, similar to the Philip Morris PPA, for separately measuring ventilation through the cigarette filter and flow through the tobacco rod; and

(e) a standard Phipps & Bird smoking machine.

The test apparatus is more fully described in the Nall Report (Exhibit E), and can be made available to the Court upon request.

20. In the ventilation tests, measurements were taken from a sample of 12 cigarettes. In smoke delivery tests using 60 Barclays taken from the same population employed for the ventilation tests, the "tar" and nicotine delivered through the cigarette filter were recorded.

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21. The significant results of these tests are summarized as follows:

(a) Cigarette ventilation decreases with decreasing insertion lengths (i.e., less filter inserted into the cigarette holder) and increasing pressures, especially when the cigarette holder simulates maximum "lip drape." However, even under these extreme, "worst case" test conditions, ventilation fell an average of 14% -- not 30% -- as Philip Morris claimed in its work with the PPA. Moreover, even at the very highest pressure level of 85 torr -- well above the average expected in human smoking -- and the shallowest insertion depth (4 mm), with maximum simulated lip drape, average tar delivery did not exceed 1.5 mg. per cigarette, well below the 4-7 mg. predicted by Philip Morris and the FTC.

(b) There is more change in ventilation rates for the relatively shorter insertion depths when tests are run on a cigarette holder fitted with a low modulus, as opposed to medium modulus, tubing.

(c) There is more variation among cigarettes at the relatively shallow insertion depths and relatively high pressures.

(d) At pressures of 175 torr, well above the highest average observed in any individual human smoker and five times the average level of 34 torr, Barclay delivers an average of 4.1 mg. tar.

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22. Clearly, the FTC's claim that Barclay delivers 3-7 mg. tar in normal human smoking is not supported by these tests -- the only tests known to have been performed in which insertion depth and lip pressure were precisely controlled. These tests demonstrate that at the upper end of the range of pressures reasonably to be expected in human smoking, and the shallowest insertion depths, with maximum lip drape -- that is, under "worst case" test conditions -- Barclay's tar delivery did not exceed an average of 1.5 mg tar per cigarette. In my opinion, these data strongly suggest that neither of the two ventilation reduction mechanisms alleged to be unique to Barclay -- neither lip drape nor channel crushing -- is a likely cause of any sizable ventilation reduction or increase in tar delivery during actual smoking. Other factors which might account for reduced ventilation and higher tar delivery, such as puff volume, puff duration, or hole blocking, can also occur in smoking of all other low tar cigarettes.

23. By establishing the effects on ventilation of limited insertion depth, these test results also show how distorted ventilation rates and tar delivery figures were produced in Philip Morris' tests with the puff parameter analyzer. Since Philip Morris' test subjects had limited filter insertion depth available to them in the PPA tests, they were more likely to occlude Barclay's ventilation grooves in those tests.

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24. The test methodology, apparatus, and results are more fully set forth in the accompanying Nall Report (Exhibit E), to which the Court is respectfully referred.

Roger D. Kamm

Roger D. Kamm

Sworn to before me this
2th day of September, 1983

Emily Bassett

Notary Public

Cambridge, MA
6/1/84

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R: REDACTED MATERIAL

ROGER D. KAMM

Curriculum Vitae

School Address

Massachusetts Institute of Technology

REDACTED

Permanent Address

REDACTED

EDUCATION

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge, Ma.

Ph.D. in Mechanical Engineering, May 1977
Thesis: "A Study of External Pneumatic Compression for the Prevention of Deep Venous Thrombosis"
Advisor: Professor A. H. Shapiro
NIGMS Fellow, Sigma Xi

S.M. in Mechanical Engineering, August 1973
Thesis: "An Acoustic Amplifier for the Detection of Atmospheric Pollutants"
Advisor: Professor C. F. Dewey, Jr.
National Science Foundation Traineeship

NORTHWESTERN UNIVERSITY, Evanston, Illinois

B.S. in Mechanical Engineering, June 1972
Tau Beta Pi, Pi Tau Sigma (Pres.), ASME (Pres.), Phi Eta Sigma
Harry Coulby Scholarship, 1968-1972

EXPERIENCE

July 1981 - present: Associate Professor of Mechanical Engineering at M.I.T. Research interests in biomedical fluid mechanics, fluid mechanics and mass transport. Teaching responsibilities in fluid mechanics, thermal sciences, and heat transfer.

July 1978 - July 1981: Assistant Professor of Mechanical Engineering at MIT.

May 1977 to July 1978: Lecturer and Research Associate in the Department of Mechanical Engineering at M.I.T.

January 1977 - May 1977: Instructor, teaching an undergraduate course in fluid mechanics at M.I.T.

June 1972 - May 1977: Research Assistant in M.I.T. Fluid Mechanics Laboratory.

HONORS

Sigma Xi, Tau Beta Pi, Pi Tau Sigma, American Men and Women of Sicence, Who's Who in the East.

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Publications of ROGER D. KAMM

1. Books

None

2. Papers in Refereed Journals

1. Dewey, C. F., Kamm, R. D., and Hackett, C. E., "An acoustic amplifier for the detection of atmospheric pollutants," Appl. Phys. Lett., 23: 11, 633-635, 1973.

2. Kamm, R. D., "Detection of weakly absorbing gases using a resonant opto-acoustic method," J. Appl. Phys., 47: 8, 3550-3558, 1976.

3. Kamm. R. D., and Shapiro, A. H., "Unsteady flow in a collapsible tube subjected to external pressure or body forces," J. Fluid Mech., 95: 1, 1-78, 1979.

4. Thrisk, R. B., Kamm R. D., and Shapiro, A. H., "Changes in venous blood volume produced by external compression of the lower leg," Medical and Biological Engineering and Computing, Vol. 18, No. 5, pp. 650-656, 1980.

5. Slutsky, A. S., Draxen, J. M., Ingram, R. H. Jr., Kamm, R. D., Shapiro, A. H., Fredberg, J. J., Loring S. H., and Lehr, J. "Effective pulmonary ventilation with small-volume oscillations at high frequency," Science, Vol. 209, pp. 609-610, 1 August 1980.

6. Kececioglu, I., McClurken, M. E., Kamm R. D., and Shapiro, A. H., "Steady supercritical flow in collapsible tubes. Part I: experimental observations," Jounral of Fluid Mechanics, Vol. 109, pp. 367-389, 1981.

7. McClurken, M. E., Kececioglu, I., Kamm R. D., and Shapiro, A. H., "Steady supercritical flow in collapsible tubes. Part II: theoretical studies," Journal of Fluid Mechanics, Vol. 109, pp. 391-415, 1981.

8. Lueptow, R. M., Karlen, J. M., Kamm R. D., and Shapiro, A. H., "Circulatory model studies of external cardiac assist by counter-pulsation," Cardiovascular Research, in press.

9. Lueptow, R. M., Karlen, J. M., Kamm R. D., and Shapiro, A. H., "Study of four modes of counterpulsative external cardiac assist (ECA)," 27th Annual Meeting of the American Society for Artificial Internal Organs, May 6-8, 1981, Anahemi, CA. To appear in the 1981 ASAIO Transactions.

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Publications of ROGER D. KAMM

3. Proceedings of Refereed Conferences

1. Scherer, P. W., Kamm R. D., and Shapiro, A. H., "External pneumatic compression for the prevention of deep venous thrombosis," Proceedings of the San Diego Bio-medical Symposium, Vol. 14, pp. 403-407, 1975.

2. Kamm, R. D., and Shapiro, A. H., "Hemodynamics of intermittent external limb compression," Fed. Proc. 10050, 1977.

3. Kececioglu, I., Kamm, R. D., and Shapiro, A. H., "Structure of shock waves in collapsible tube flow," Proceedings of the 31st Annual Conference on Engineering in Medicine and Biology, 1978.

4. Thirsk, R. B., Kamm, R. D., and Shapiro, A. H., "Venous compliance of calf at negative transmural pressure," Proceedings of the 31st Annual Conference on Engineering in Medicine and Biology, 1978.

5. Kamm, R. D., and Shapiro, A. H., "The unsteady collapse of a compliant tube subjected to uniform external pressure," Proceedings of the 31st Annual Conference on Engineering in Medicine and Biology, 1978.

6. Olson, D. A., Kamm, R. D., and Shapiro, A. H., "Experimental studies of external pneumatic compression methods on a model human leg," Proceedings of the 32nd Annual Conference on Engineering in Medicine and Biology, 1979.

7. Hollars, M. G., Kamm, R. D., and Shapiro, A. H., "Comparison of intermittent external compression methods," Proceedings of 32nd Annual Conference on Engineering in Medicine and Biology, 1979.

8. Venegas, J. G., Kamm, R. D., and Shapiro, A. H., Abstract: "A simple pulmonary model of forced expiration," Proceedings of the 33rd Annual Conference on Engineering in Medicine and Biology, Washington, D. C., 1980.

9. Johnson, M. C., Kamm R. D., and Shapiro, A. H., Abstract: "A model for the flow of aqueous humor from the eye," Proceedings of the 33rd Annual Conference on Engineering in Medicine and Biology, Washington, D. C., 1980.

10. Lueptow, R. M., Karlen, J. M., Kamm R. D., and Shapiro, A. H., Abstract: "Model studies of external cardiac assist by counter-pulsation," Proceedings of the 33rd Annual Conference on Engineering in Medicine and Biology, Washington, D.C., 30 Sept. - 3 Oct. 1980.

11. Kamm, R. D., Joshi, C., Slutsky, A. S., and Drazen, J. M., "Ventilation by high frequency, low volume oscillations," Proceedings of the 33rd Annual Conference on Engineering in Medicine and Biology, Washington, D.C., 1980.

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12. Slutsky, A. S., Drazen, J. M., Kamm, R. D., Loring, S. H., Lehr, J., Ingrams, R. H. Jr., and Shapiro, A. H., Abstract: "The effect of lung volume on CO_2 elimination by high frequency ventilation (HFV)," Joint Fall Meeting of the APS, Toronto, Canada, October 12-17, 1980.

13. McClurken, M. E., Kececioglu, I., Jan, D. L., Parton, R. A., Kamm, R. D. and Shapiro, A. H., Abstract: "Supercritical flow in collapsible tubes," 1980 Centennial Winter Annual Meeting of the ASME, Chicago, Illinois, November 16-21, 1980. 1980 Advances in Bioengineering, pp. 293-296.

14. Jan, D. L., Parton, R. A., Kamm R. D., and Shapiro, A. H., Abstract: "Unsteady flow in a partially collapsed compliant tube under axial tension," 1980 Centennial Winter Annual Meeting of the ASME, Chicago, Illinois, November 16-21, 1980. 1980 Advances in Bioengineering, pp. 289-292.

15. Froelich, J., Kamm, R. D., Shapiro, A. H., McKusick, K. A., and Strauss, H. W., Abstract: "Effect of external pneumatic compression on venous volumes of the calf," 28th Annual Meeting of the Society of Nuclear Medicine,

16. Johnson, M. C., Kamm R. D., and Shapiro, A. H., Abstract: " A model for the flow of aqueous Humor through Schlemm's canal," Supplement to Investigative Ophthalmology and Visual Science, Vol. 20, No. 3, p. 28, 1981.

17. Rossing, T. H. Slutsky, A. S., Lehr, J., Ingram, R. H., Kamm, R. D., Shapiro, A. H., and Drazen, J. M., Abstract: "The influence of tidal volume (V_T) on CO_2 output ($\dot{V}_{CO_2}$) during high frequency ventilation (HFV) in dogs," Federation Proceedings, Vol. 40, p. 384, 1981.

18. Kamm, R. D., Joshi, C. H., Minnichelli, M. D., Mahoney, G. T., Shapiro, A. H., Slutsky, A. S. and Drazen, J. M., Abstract: "Experimental Measurements in a univorm tube of the effective diffusivity in oscillatory flow," Federation Proceedings, Vol. 40, p. 1981.

19. Rossing, T. H., Slutsky, A. S., Loring, S. H., Ingram, R. H. Jr., Kamm, R. D., Shapiro, A. H., and Drazen, J. M., Abstract: "Effects of histamine induced bronchoconstriction on gas exchange by high frequency ventilation in dogs," Federation Proceedings, Vol. 40, p. , 1981.

20. Lichter, S., Kamm, R. D., and Shapiro, A. H., "Unstable oscillations at an elastic jump in a compliant tube," to be presented at the 34th Annual Conference on Engineering in Medicine and Biology, to be held in Houston, Texas, 21-25 September 1981.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

21. Battaglioli, J. L., and Kamm. R. D., "The collapse of small vessels in the wall of a spherical cavity," accepted for publication in the Proceedings of the 34th Annual Conference on Engineering in Medicine and Biology, Houston, Texas, 1981.

5. Internal Memoranda and Progress Reports

None

6. Invited Lectures

1. February 1979, " The Hemodynamics of External Pneumatic Compression, "Kendal Corporation, Research Division, Barrington, Illinois.

2. May, 1981, "Mechanisms of Gas Exchange in High Frequency Ventilation," AAMI 16th Annual Meeting, Washington, D. C..

3. June, 1981, "Pressure Cycles for External Pneumatic Compression," Presented at a conference organized at the NIH on the Rheologic Contributions to Thrombosis and Hemostasis, Bethesda, Maryland.

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R. Kamm 6-25-83

Proposed design for FTC holder

Design rationale. This design is intended to provide a more realistic simulation of the filter-lip mucosal relationship found during normal smoking. It is not our objective to merely match ventilation figures obtained with a PPA or similarly artificial device, but rather to reproduce those conditions which may impair ventilation in the real smoker. In this regard, the following factors need to be considered and properly mimicked in the test apparatus:

1) Pressures exerted on the cigarette filter
2) Total area of filter surface exposed to lip pressure
3) Depth of insertion, i.e. the location of the region of lip contact with respect both to the vent holes and filter end.

These are considered by us (B&W) to be the major factors influencing the possible obstruction of ventilation flow and, if properly accounted for, will produce ~~measures of ventilation yield~~ values of ventilation consistent with normal smoking.

The first two factors provide for a realistic simulation of possible groove collapse anywhere along the length of

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the ventilation channels while the last pertains to the possible occlusion of vent grooves due to "lip drape" at the mouth end of the filter.

Proposed design. The design shown in the figure retains the simplicity of previous holders but incorporates the important design considerations mentioned above. The holder consists of a rigid cylinder onto which is mounted a specially fabricated silicone rubber tube (see figure). To this extent, our proposed design ~~can~~ resembles both the Borgwaldt and Filtrona holders. The tube used in our design, however, has a very thin wall (dimension yet to be determined) and a diameter (when unstretched) which closely matches that of a cigarette (~8 mm). This tube is mounted onto the rigid holder ~~so that when~~ in a totally relaxed state so that there is no initial stretch. Mounting the tube in this way, (in combination with the thin-wa ensures that the pressure acting on the filter will be equal to that supplied to the air chamber within the holder. During the FTC test to measure yields of nicotine and tar this pressure should be maintained at a level typical of normal smoking; in the range of 30 to 100 torr (see earlier report of R. Kamm ... date ...).

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While similar in some respects, ~~to~~ this design differs from both the Borgwaldt and Filtrona holders in that the pressure applied to the filter and the relationship of contact between the filter and lips can be directly determined and set to values deemed appropriate for the simulation of normal smoking.

The dimensions indicated in the figure pertain to the following measureable smoking parameters:

A = total width of lip $\overset{?}{\cong}$ 12 mm

B = normal insertion depth $\cong$ 9 mm

where the dimensions given reflect our current best estimates. These ~~figures~~ values should, however, be determined in a carefully controlled study.

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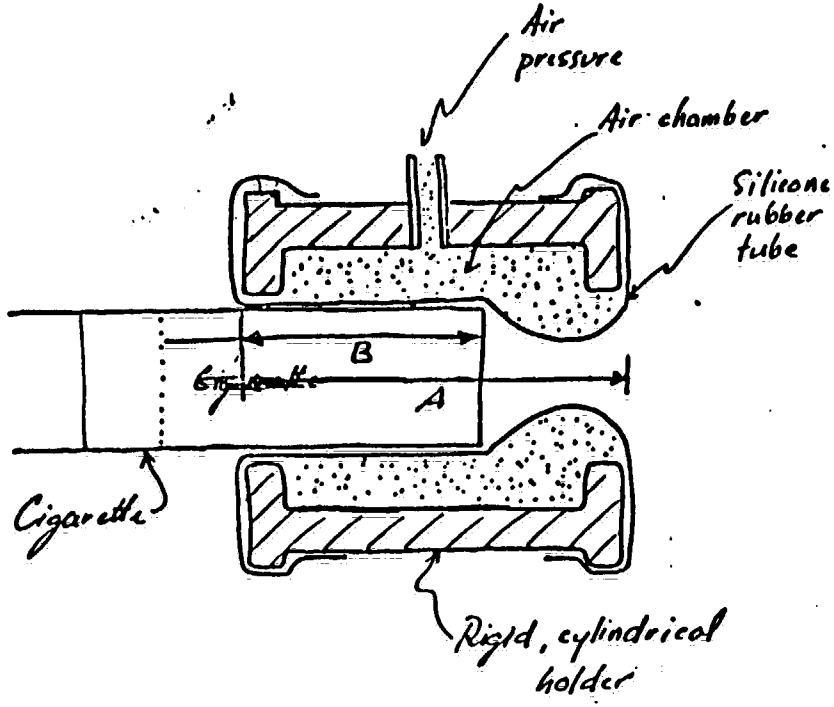
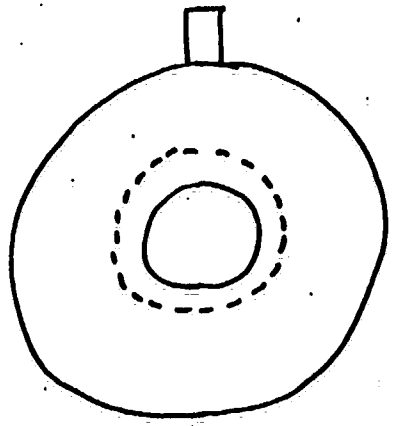
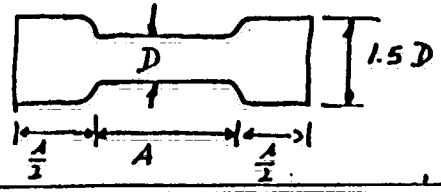


X-Sectional View



End view

Silicone rubber tube



; D = cigarette diameter

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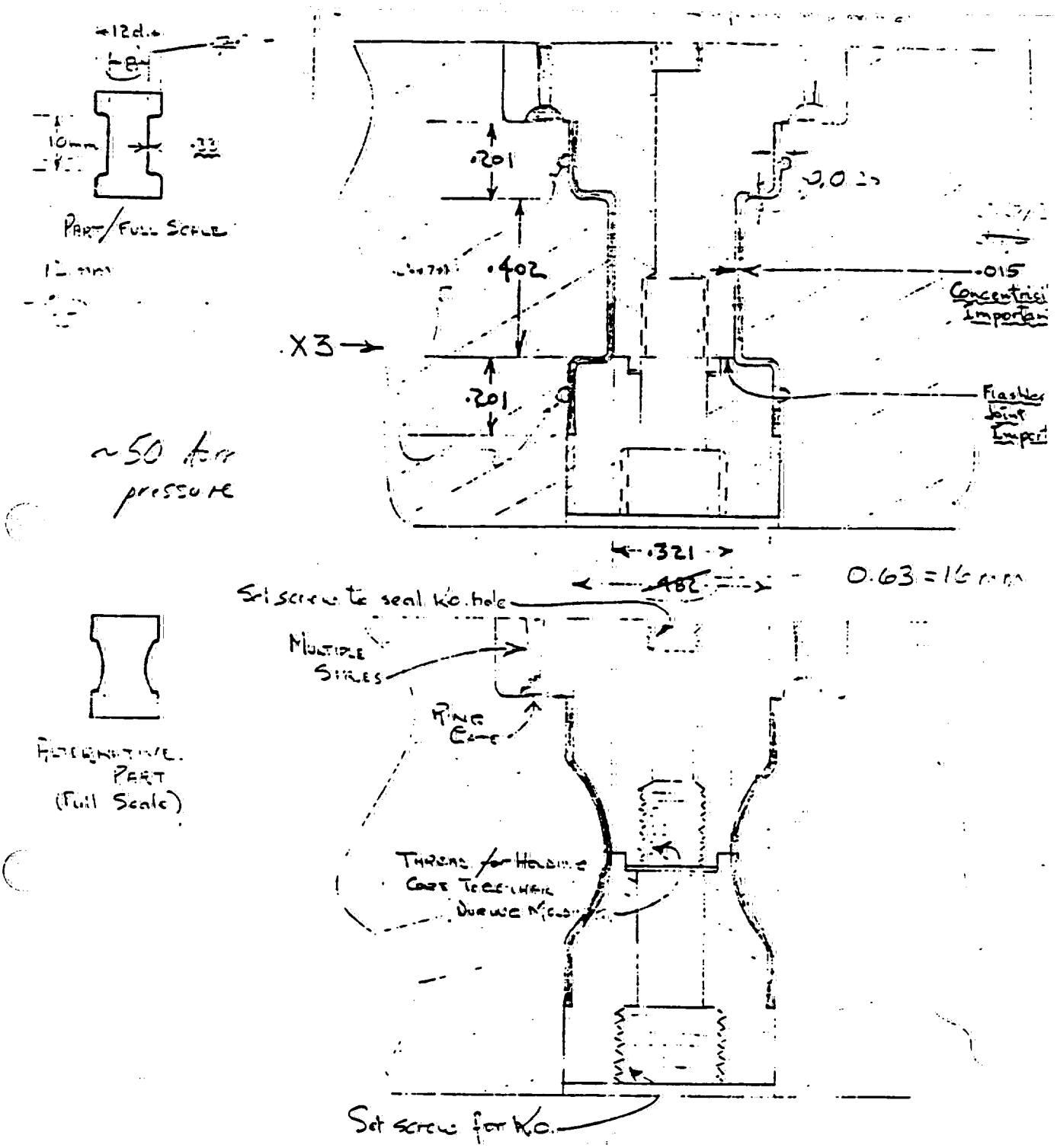

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JUNE 29/83

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PRESSURE MEASURING TESTS

SERIES A - RICH LIGHTS
SERIES B - BARCLAY

Brown & Williamson Tobacco Co.
1600 W. Hill St.
Louisville, Ky. 40201

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2023100024

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Report Summary

Objective. The purpose of these tests was to determine the pressures exerted on the surface of a cigarette filter (i) by human lips in normal smoking conditions and (ii) by three types of filter-holders; the Cambridge, Filtrona, and Borgwaldt holders.

Method. To measure surface pressures a special measurement system was developed. A small (~ 1 to 2 mm dia.) latex bulb was mounted directly onto the filter and attached via a short section of hypodermic needle tubing and a teflon catheter to a low compliance pressure transducer. The entire system was filled with water to avoid the effects of air compression, and calibrated prior to each series of measurements.

Lip pressures were measured on twelve subjects during normal smoking. From 8 to 12 measurements were made on each subject, 5 with the sensing bulb positioned against the upper lip, and 5 with the bulb against the lower lip. The transducer output was observed on an oscilliscope and the maximum reading for each puff was recorded. Three average pressures were computed for each subject: upper lip average, lower lip average, and overall average.

Filter-holder pressures were determined by adjusting the cigarette position within the holder until the maximum reading was achieved. An average reading was determined for each of the three filter holders.

Conclusions. Results of this study indicate that human lips exert an average pressure of about 34 torr. Each of the three filter holders exert greater pressures as follows: Cambridge, 1.4 times as large as the average lip pressure; Borgwaldt, 3.5 times as large; and Filtrona nearly

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15 times as large. It follows, then, that the Filtrona holder represents the poorest approximation to human lips while the Cambridge holder is the closest, given the three classes of holders tested.

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Introduction

Tests were conducted to determine the pressures exerted on the surface of a cigarette filter by human lips and by several types of filter-holder: the Cambridge, Borgwaldt, and Filtrona holders. Measurement of surface pressure on a small portion of the filter surface necessitated the development of a special measurement technique. With this technique, a small, very compliant latex rubber bulb is attached to the cigarette surface and connected via stiff tubing to a low compliance pressure transducer. This entire system (bulb, tubing, and transducer) is filled with water to minimize the change in volume of the latex bulb during compression.

When lips or a filter-holder come into contact with the bulb, the external forces cause pressure inside the bulb to rise. As long as the bulb remains partially inflated, the pressure sensed by the transducer reflects the pressure applied to the bulb surface. Due to the low compliance of the water-filled system, the contained volume of the bulb changes very little, even for surface pressures approaching 500 torr. Since the test probe is so small, the normal contour of the lips and of the filter holders is minimally affected.

Measurement Apparatus

The complete measurement system is shown schematically in Fig. 1. The latex test probe (~ 1 to 2 mm dia) is secured using a contact adhesive to a small (~ 2 mm dia) exposed portion of the cigarette,

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approximately 7 to 9 mm from the filter tip. The sensing bulb slides over the end of a 1 cm length of 22 gage hypodermic needle tubing which is glued to the filter paper. The needle tubing attaches to a 2 ft. length of teflon catheter (~ 1 mm I.D.) which leads to the low compliance ($< 10^{-9}$ $cm^3/dyne/cm^2$) pressure transducer (Gould Statham P 23 Series). The output of the transducer is amplified using a variable gain low-noise amplifier and displayed on an oscilliscope.

Because the bulb had a non-linear response to contact pressure, it was necessary to calibrate each instrumented cigarette. This was accomplished using the calibration device shown in Fig. 2, consisting of a thin-walled latex tube mounted within a rigid plexiglas enclosure. This geometry was chosen for its close resemblance to the lip configuration. Pressure to the calibration device was controlled using a 10 psig pressure regulator and measured by a mercury manometer. When pressurized, the tube exerted a measured contact stress on the cigarette filter.

Test Procedure

a) Filter-holder measurements. The test probe was placed on the cigarette filter and calibrated over the range of anticipated pressures using the device described above. Filter-holder pressures were then measured using each of the following:

Cambridge holder. The latex sheet used in this test was the industry standard, 0.20-0.23 mm thick with a 3 mm dia hole. When stretched onto the holder, the latex hole diameter increased to 3.9 mm.

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Borgwaldt holder. The standard latex rubber sleeve was used which has a 7 mm O.D. with a wall thickness of 0.36-0.43 mm.

Filtrona. A latex sleeve of 6 mm O.D. and 0.38 mm wall thickness was used. The sleeve used was provided by R.J. Reynolds.

In each case, several pressure measurements were made at or near the position of peak pressure. The average values of pressure determined for each series of measurements were as follows: Cambridge; $\bar{p}$ = 47 torr, Borgwaldt; $\bar{p}$ = 118 torr, and Filtrona; $\bar{p}$ = 500 torr.

b) Human lip-pressure measurements. Prior to each test, a probe was mounted on a fresh cigarette and calibrated over the range of anticipated pressures, typically up to 250 torr. Occasionally the baseline would drift during the course of calibration indicating a leak in the system. When this occurred, the leak was repaired before measurements were made.

When the cigarette was calibrated, the subject was brought into the testing room and seated comfortably at a table. The subject was then instructed to insert the cigarette so that the sensor was centered on their lip and to smoke in a normal fashion, at a normal pace. In the first six tests the subject was asked to smoke with the bulb against the top lip for the first 3 to 5 puffs, then against the bottom lip for the remaining 3 to 5 puffs. In the last 7 tests, the procedure was reversed; first the bottom lip, then the top.

For each puff, the pressure excursions were observed on an oscilliscope screen and the peak excursion during each puff was recorded. Each individual had a unique pressure trace, the shape of which was fairly consistent. Typically, the pressure would rise rapidly to a first maximum as the lips

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contacted the probe, then fall to a lower value, then rise to a second maximum before falling to zero. This same general pattern can be seen in the sample traces of Fig. 3.

At the end of each session, the subject was questioned concerning the location of the probe and their general impressions during the test. The information thus obtained helped us to refine the technique in subsequent tests.

Test Results

Twelve subjects were tested using the procedure described above. The results for the first subject, however, were omitted from the study for the following reason. As a result of the mounting procedure, much of the filter cover had been removed, leaving large sections of the filter exposed. Consequently, the subject needed to draw much harder than normal in order to get enough smoke, causing pressures in excess of 300 mm Hg. In all subsequent tests, only a small section of filter paper was removed. To compensate in part for the added ventillation, the vent holes in the filter were taped closed. A second subject (subject 7) was re-tested because a pin-hole had inadvertently been made in the cigarette paper during probe mounting. Only the second set of data was used. Subject 9 was tested twice to examine the consistency of our measurements; both sets of results are presented.

The raw data for all tests are presented in Appendix A including the individual calibration curves. These results are summarized in Table 1 in terms of:

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(i) pressure developed during lighting, p_L;

(ii) mean upper-lip pressure, p_u;

(iii) Mean bottom-lip pressure, p_b; and

(iv) overall mean lip pressure, $\bar{p}$.

The mean value and standard deviation of each parameter is given in Table 1 for all subjects. A graphical representation of the results is shown in Fig. 4 including the pressures exerted by each of the three filter-holders tested. As seen in the figure, the Cambridge holder exerts pressures only slightly higher than the mean lip pressure, the Borgwaldt exerts a pressure about 3.5 times as great, and the Filtrona creates a surface pressure 15 times as great. Among the three filter holders tested, the Cambridge holder most closely approximates the pressure level produced by human lips.

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Table 1. Data Summary

Filter holders:

Cambridge - $\bar{p}$ = 47 torr (2 measurements)
Borgwaldt - $\bar{p}$ = 118 torr (3 measurements)
Filtrona - $\bar{p}$ = 500 torr (15 measurements)

Lip-pressures

Subject	Upper lip (p_u)	Bottom lip (p_b)	Overall ($\bar{p}$)	Lighting (p_L)
1	(no useful data -- see text)			
2	87	110	98.5	100
3	40	16	28	53
4	2.5	2.9	2.7	13
5	60	71	65	100
6	53	6.0	29	11.3
7	57	3.9	30	10[a]
8	88	4.4	46	3.4[a]
9A	10) 7.5	16) 13.2	13) 10.4	8.8[a]) 13.2
9B	5.1	10.4	7.8	17.5[a]
10	16.7	15.5	16.1	12.5[a]
11	51.3	3.3	27.3	3.8[a]
12	18	25	21.5	7.5[a]
Average (s.d.)	43.7 (29.7)	24.7 (34.4)	34.2 (32.9)	55 (44.0)/8.4 (4 29.8 (37.2)[b]

(a) Lighting with bulb on lower lip

(b) Upper lip/Lower lip. Overall average directly below.

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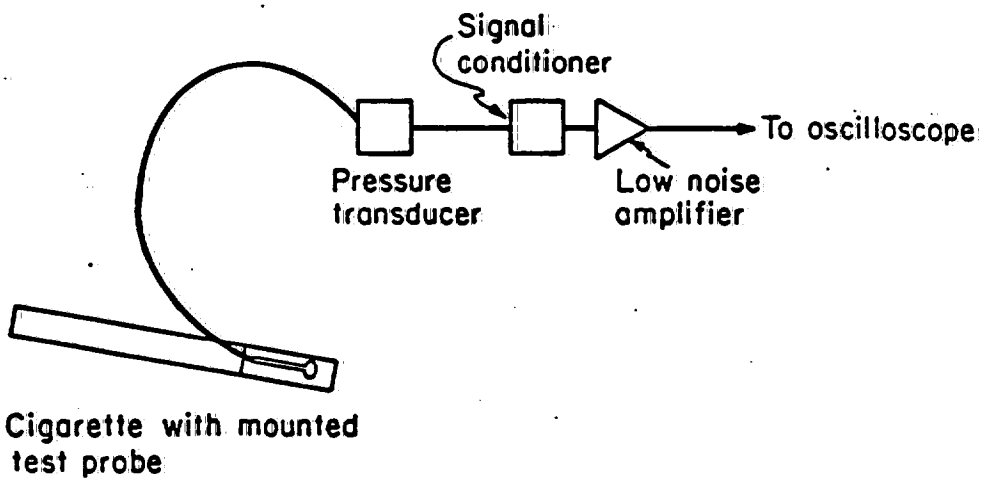

Figure 1(a). Schematic of test apparatus.

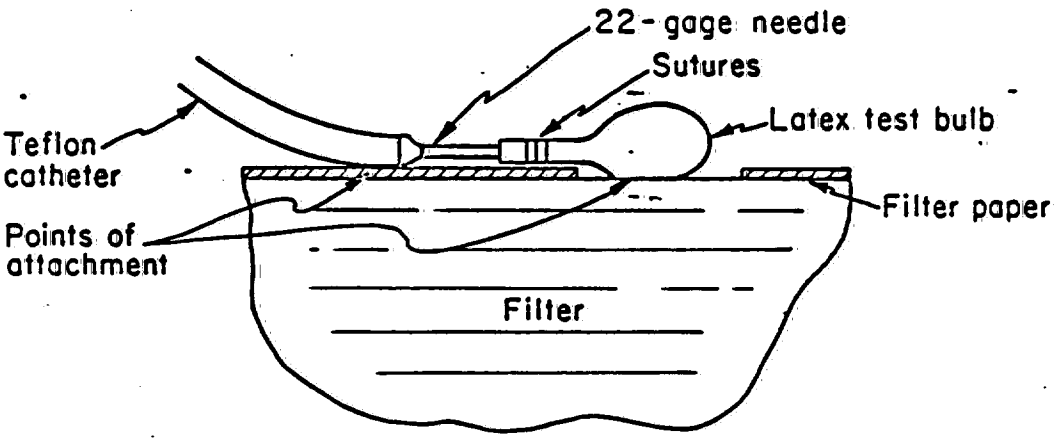

Figure 1(b). Detailed sketch of test probe.

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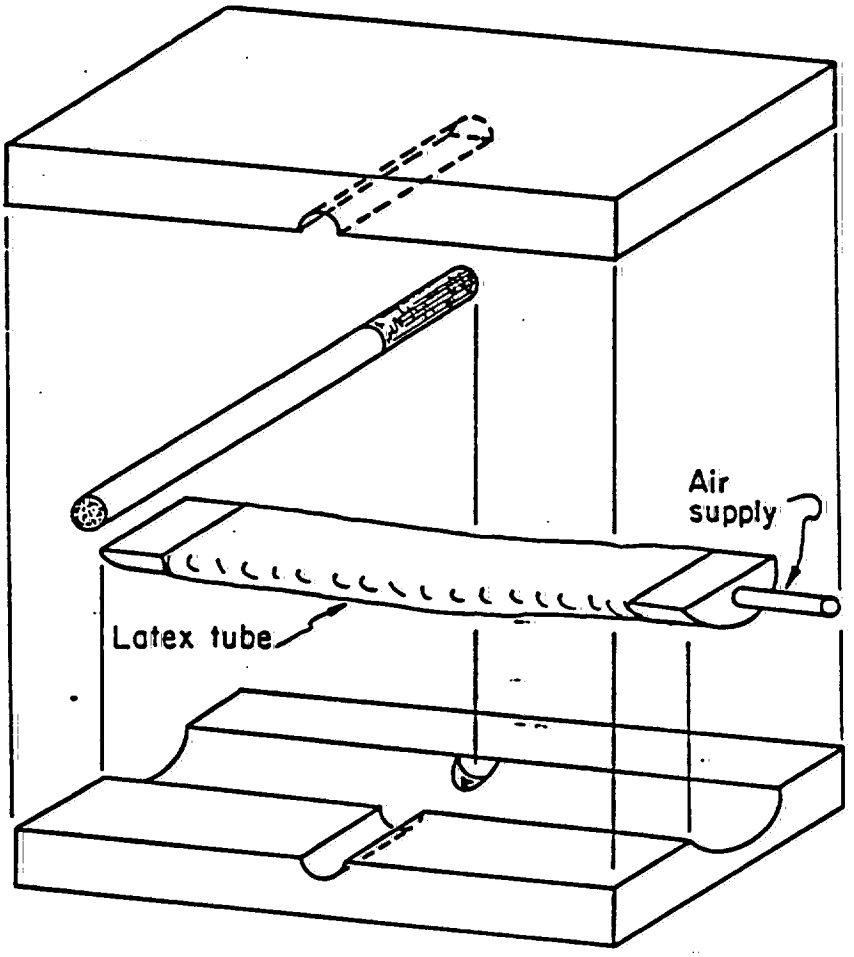

Figure 2. Assembly drawing of calibration device.

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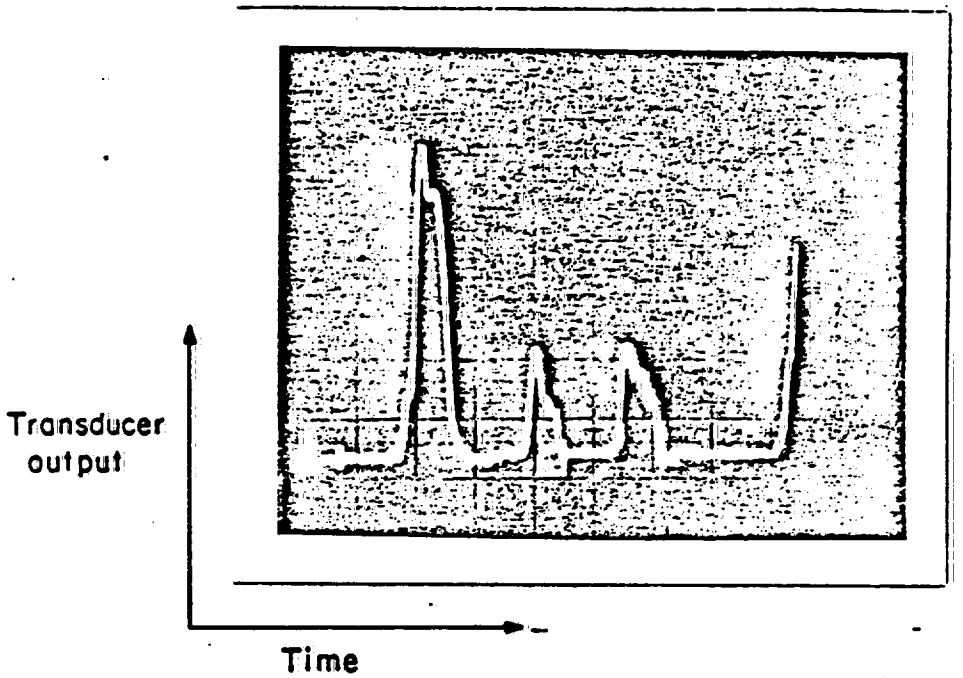

Figure 3. Three puff profiles as recorded on the oscilliscope.

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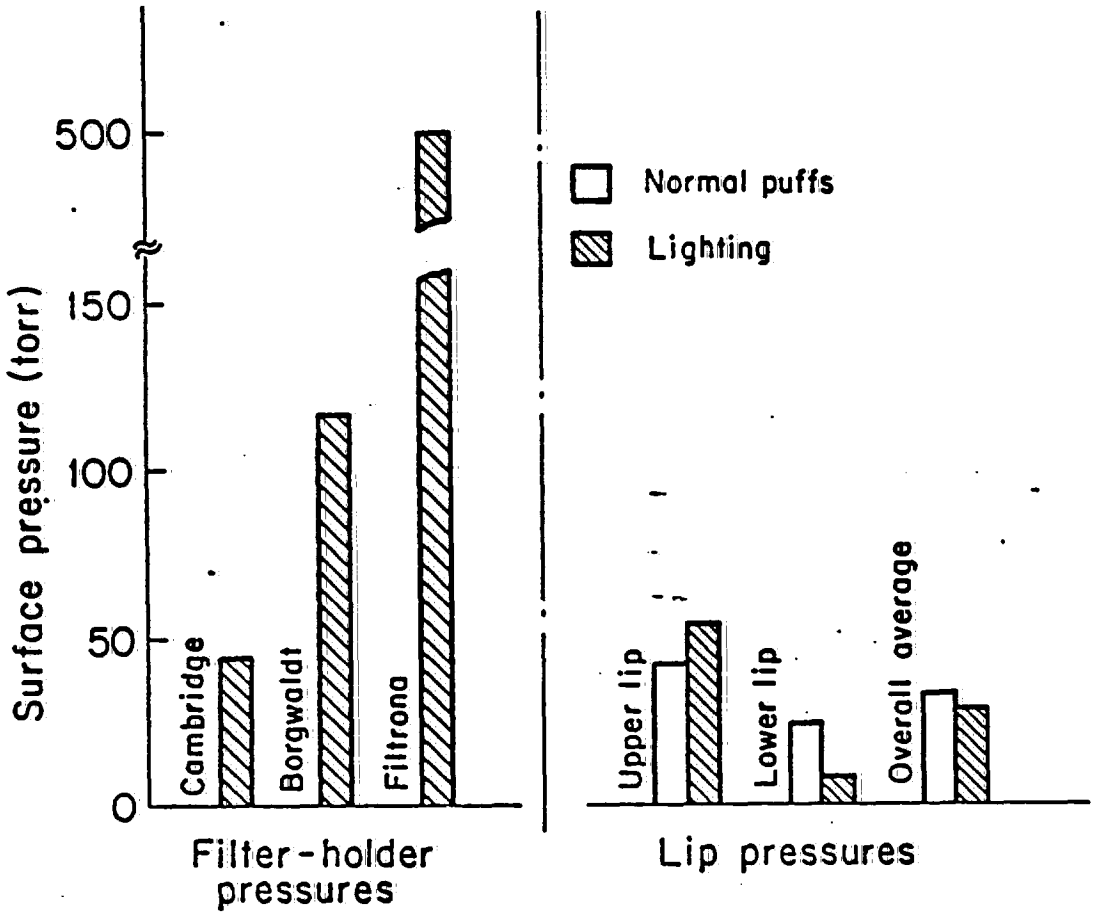

Figure 4. Summary of Test Data.

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APPENDIX A

EXPERIMENTAL DATA

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Test Data Sheet

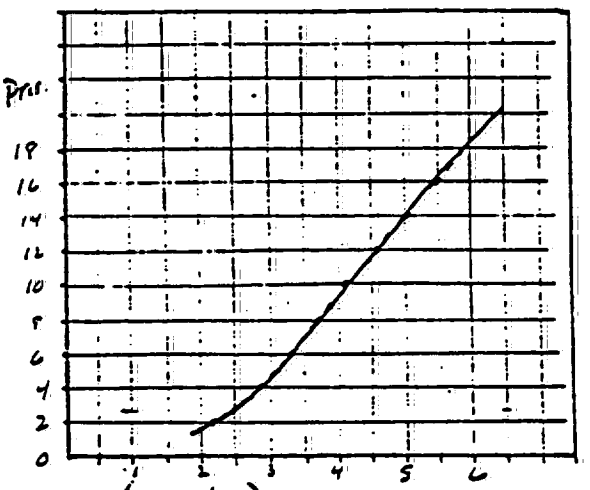
Date 5-30 Time 5:10 Subject #~~[illegible]~~ Heidiers Sex ___

Weight ~~[illegible]~~ Cambridge Height ___

Comments ___

CALIBRATION

Pressure (in Hg)	Output voltage (0.5v/cm)
0	0
2	2.2
4	2.8
6	3.3
8	3.7
10	4.1
12	4.6
14	5.0
16	5.5



(0.5v/cm)

TEST RESULTS

Measurement #		Maximum scale reading	Photograph	Pressure
1	Borgwaldt (7mm OD tube)	3.0		4.7 } = 115
2		3.0 ~125 torr		4.7
3		2.0		1.8 } 43 torr
4	Cambridge	2.0 (2.3 max) ~46 torr		1.7
5				2.2 = 55 t
6	Filtrona ①	6.0 6.5		
7		6.3 6.3		
8	(6mm OD tube)	5.9		
9	②	6.8 6.1 Avg = 6.4		20 = 500 to
10	Filtrona	7.0 6.7		
		7.1 6.4 ~ 470 torr		
		7.1 6.2		
		6.4 6.0		

Test comments:

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Test run Ventilation pro

Too much exposed filter area

Test Data Sheet

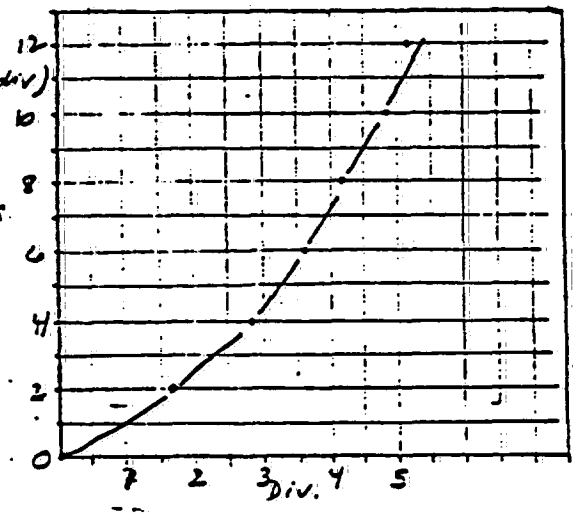
Date 5-30 Time 11:30 Subject # 1 Sex F

Weight _____ Height _____

Comments No photographs taken - probe read directly from scope.

CALIBRATION 0 0 V

Pressure (inches Hg)	Output voltage (0.5 V/div)
2	1.7 div
4	2.8
6	3.6
8	4.2
10	4.8
12	5.2



TEST RESULTS

Measurement #		Maximum scale reading	Photograph
1	Bulb on top throughout	6.5	
2		3	
3		6.5	
4		Off scale	
5		~7+	
6	Change scale p.d. V/div	7	
7		2	
8		6	
9		5	
10		4	
		5	
		5	

Put on more tape to reduce leakage into filter

Test comments:

Don't use

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Test Data Sheet

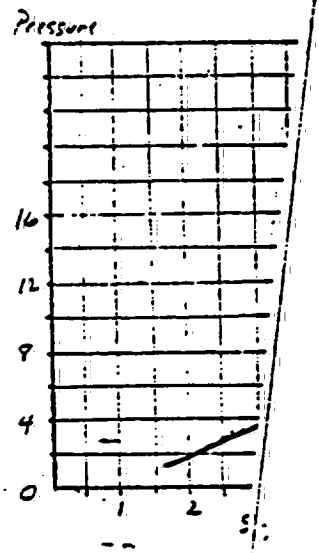
Date 5-30 Time 1:00 Subject # 2 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

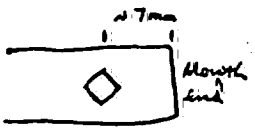
Pressure (in Hg)	Output ~~voltage~~ (volts/cm) cm
0	0
4	3.2
8	4.7
12	6.1
16	7.4



TEST RESULTS

Measurement #		Maximum scale rea
1	Lighting	3.2
2	Bed on top lip	2.0
3		2.8
4	↑	3.2
5	Bed on Bottom Lip ↓	2.8
6		2.4
7		4.2
8		2.0
9		4.2
10		

Test comments:



Now using a single window in tipping/plug wrap

Date

Commen

CALIBRA

Pressur

0
2
4
6
8
10
12
14

TEST RESULT

Measurement

1
2
3
4
5
6
7
8
9
10

Test comments:

7 m

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Test Data Sheet

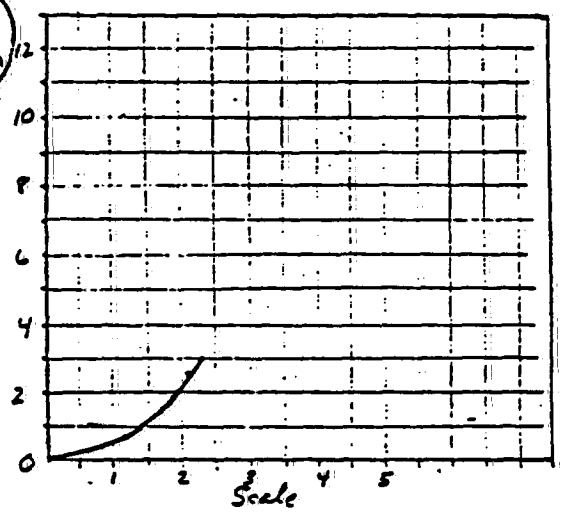
Date 5-30 Time 1:50 Subject # 3 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output ~~voltage~~ (0.2v/cm)	P	O (After Smoked (0.2v/cm)) cm
0	0		0
2	2.1	0	0
4	2.9	1.0	1.4
6	3.2	1.5	1.7
8	3.5	2.0	1.9
10	3.9	2.5	2.1
12	4.1	3.0	2.3
14	4.3		



TEST RESULTS

Measurement #		Maximum scale reading	" Hg	Torr	Photograph
1	Lighting	2.0	2.1	53	
2		2.0	2.1	53	
3		2.0	2.1	53	
4		1.0	0.6	15	
5	Bottom Lip	1.0	0.6	15	
6		1.0	0.6	15	
7		1.2	0.7	18	
8		1.2	0.7	18	
9		0.8	0.5	13	
10					

$p_L = 53$, $p_u = 40$, $p_B = 16$ $\bar{p} = 28$

Test comments:

7mm window position

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Test Data Sheet

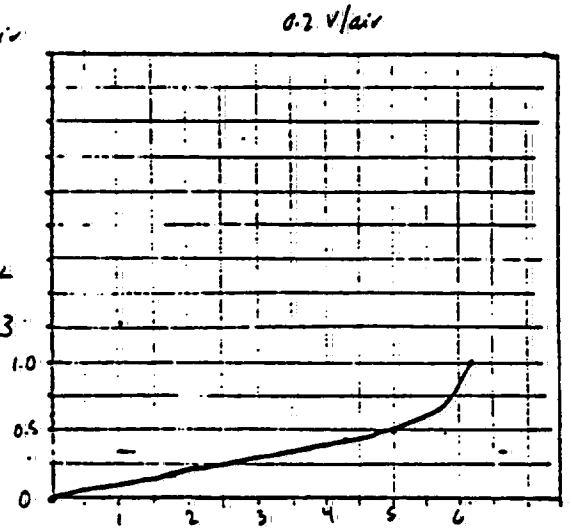
Date _____ Time 2:45 Subject # 4 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION 1.0 V/div 0.2 v/div

Pressure		Output voltage		
0		0		
1	0	1.6	0	0
2		1.9		
3	0.5	2.1	0.5	5
4		2.3		
5	1.0	2.5	1.0	6.2
6		2.7		
7	0.45	2.9	0.45	4.3
8		3.1		
9		3.3		
10		3.4		
11		3.6		
12		3.7		



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
			mHg	mm
1	Lip Ming 1.0/div	1.0	0.5	13
2	0.5/div			
3	0.2/div	0.7	0.18	2.5
4		0.7	0.18	2.5
5		0.7	0.18	2.5
6	Bottom lip	1.0	0.15	3.8
7		0.7	0.10	2.5
8		0.6	0.12	3
9		0.3	0.08	2
10				

$p_L = 13$, $p_u = 2.5$, $p_b = 2.9$

$\bar{p} = 2.7$

Test comments:

Window / 7 mm

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Test Data Sheet

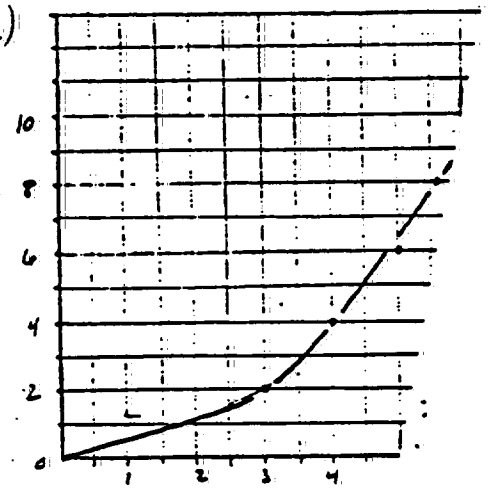
Date 5-30 Time 3:55 Subject # 5 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5v/in)
0	0
2	3.0
4	4.0
6	5.0
8	5.6
10	6.4
12	7.2



TEST RESULTS

Measurement #		Maximum scale reading	" Hg	to
1	Lighting	4.0	4	1
2		3.0	2	
3		2.7	1.7	
4		3.8	3.5	
5		3.2	2.4	
6	Bottom lip	2.9	2.9	
7		3.9	3.8	
8		3.3	2.6	
9		2.9	2.9	
10		3.0	2	

$p_L = 100$ p_u

Test comments:

Window / 7mm
Said felt normal, took normal puffs.
(a left sided smoker)

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Test Data Sheet

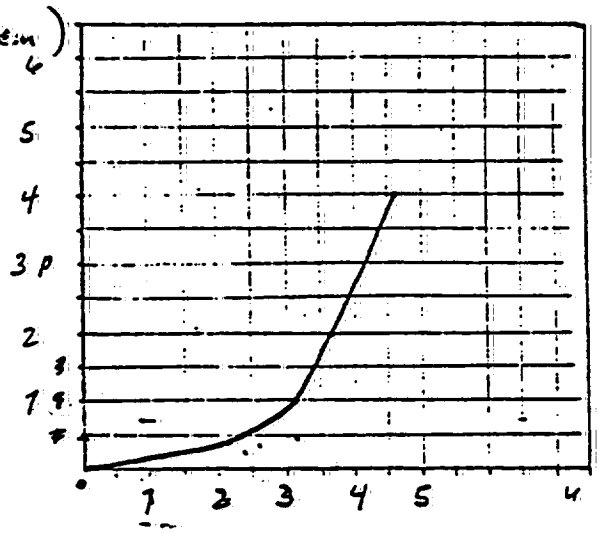
Date 5-30 Time 4:35 Subject # 6 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage
0	0
0.5	2.4
1	3.1
2	3.7
4	4.6
6	5.4
8	6.0
10	6.2



TEST RESULTS

Measurement #		Maximum scale reading	" Hg	Photograph torr
1	Lighting	2.3	0.45	11.3
2		3.4	1.5	38
3		4.2	3.1	78
4		3.7	2	50
5		3.6	1.9	45
6	Bottom	1.8	0.3	7.5
7		1.4	0.2	5
8		1.2	0.15	3.8
9		1.8	0.3	7.5
10				

$p_L = 11.3$ $p_u = 53$ $p_b = 6.0$ $\bar{p} = 29.5$

Test comments:

Window / 7 mm

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DATA NOT USED

Test Data Sheet

Hole in Tob Suction Paper

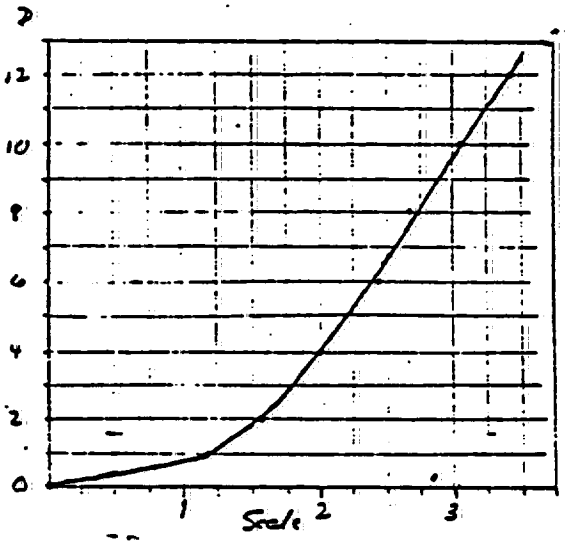
Date 5-31 Time 9:05 Subject # 7A Sex M

Weight _____ Height _____

Comments _____

CALIBRATION 0.5 v/cm

Pressure	Output voltage
0	0
1	1.2
2	1.6
4	2.0
6	2.4
8	2.7
10	3.1
12	3.4



TEST RESULTS

Measurement #		Maximum scale reading	Photograph
1	Lighting (Bottom)		
2	0.2 v/cm	0.5	
3		1.5	
4		0.8	
5		0.5	
6	(Top)	1.2	
7		0.8	
8		0.7	
9		0.5	
10			

Test comments:

Window 7mm

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Repeat

Test Data Sheet

Date 5-31 Time 10:10 Subject # 7 Sex M

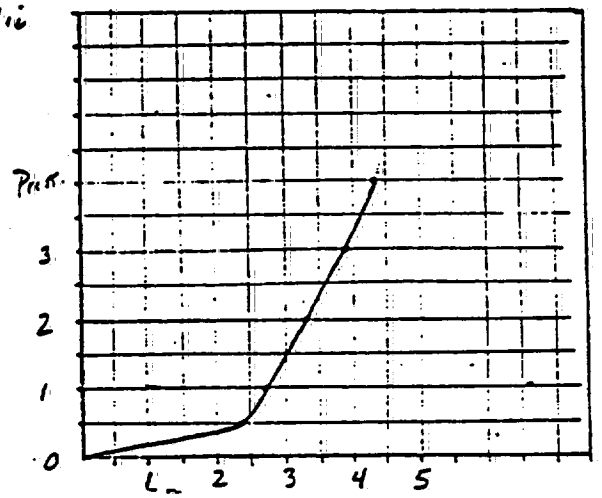
Weight _____ Height _____

Comments _____

CALIBRATION

.5 V/div

Pressure	Output voltage
.5	2.4
1.0	2.7
2.0	3.3
3.0	3.9
4.0	4.3
5.0	4.6
6.0	4.9
7.0	5.1
8.0	5.4
9.0	5.6
10.0	5.9



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
1	Lighting	2.0	0.4	10
2		0.7	0.10	2.5
3	Scale 0.2 V/div	1.2	0.05	2
4		1.4	0.10	2.5
5		3.0	0.25	6.3
6		3.0	0.25	6.3
7	Top	6.0	10.2	255
8	0.5 V/div	2.2	0.45	11.3
9		1.2	0.25	6.3
10		1.2	0.25	6.3
		1.2	0.25	6.3

Test comments:

$p_L = 10$ $p_u = 57$ $p_E = 3.9$ $\bar{p} = 30$

Window / 7 min

2023100046

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

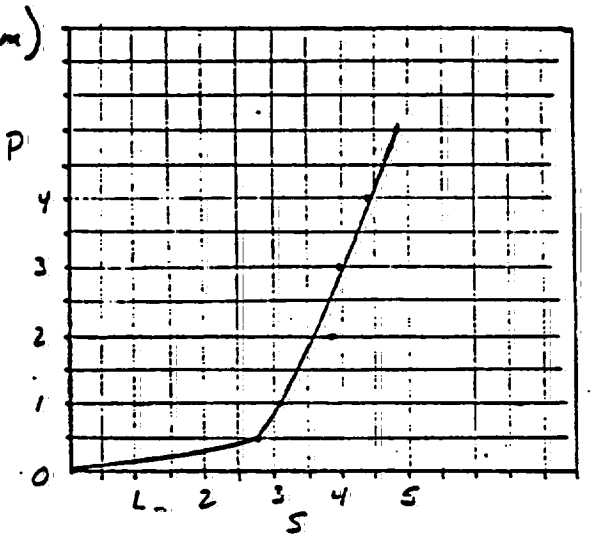
Date 5-31 Time 9:30 Subject # 8 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (mHg)	Output voltage (0.5V/cm)
0	0
0.5	2.8
1	3.1
2	3.8
3	3.9
4	4.4
5	4.8
6	5.1
7	5.4
8	5.8
9	6.1
10	6.6



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
1	Lighting	0.8	0.15	3.4
2		0.7	0.12	3
3		1.0	0.19	4.5
4		1.2	0.20	5.0
5		1.2	0.20	5.0
6	Top	2.8	0.5	12.5
7		2.9	0.7	17.5
8		6.5	9.8	245
9		4.0	3.0	75
10				

$p_L = 3.4$ $p_u = 8.8$ $p_b = 4.4$ $\bar{p} = \cancel{5.0}\ 4.6$

Test comments: Window / 7mm

"Belt was puffing abnormally"

2023100047

Test Data Sheet

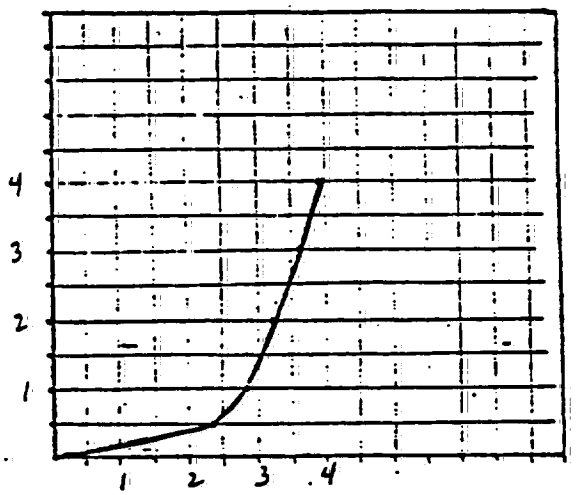
Date 5-3 Time 11:00 Subject # 9A Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5v/cm)
0	0
0.5	2.4
1	2.8
2	3.2
3	3.6
4	3.9
5	4.2
6	4.5
7	4.6
8	4.9
9	5.2
10	5.4



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
1	Lighting (Ex Hom)	2.6	0.7	17.5
2		2.3	0.95	24
3		1.4	0.3	7.5
4		1.5	0.25	6.3
5		0.7	0.15	3.8
6	Top	0.8	0.18	4.5
7		0.8	0.18	4.5
8		0.9	0.20	5.0
9		1.2	0.23	5.8
10		1.2	0.23	5.8

$p_L = 17.5$, $p_u = 5.1$, $p_b = 10.4$, $\bar{p} = 7.8$

Test comments:

Window / 7mm

2023100048

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Repeat-

Test Data Sheet

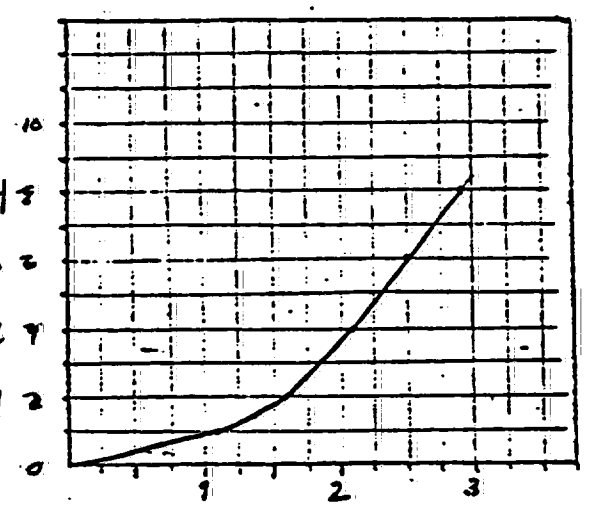
Date 5-31 Time 12:00 Subject # 9B Repeat Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5v/cm)
0	0
0.5	1.1
1	1.6
2	2.1
3	2.5
4	2.9
5	3.1
6	3.4
7	3.7
8	4.0
9	4.3
10	4.5



TEST RESULTS

Measurement #		Maximum scale reading		Photograph (cm)
1	Lighting (bottom)	0.8	0.35	8.8
2		1.0	0.45	11.3
3		1.4	0.75	18.8
4		1.4	0.75	18.8
5		1.2	0.60	15
6	Top	1.0	0.45	11.3
7		0.8	0.35	8.8
8		0.8	0.35	8.8
9		1.0	0.45	11.3
10		0.9	0.40	10

$p_l = 8.8$, $p_u = 10.0$, $p_b = 16.0$, $\bar{p} = 13.$

Test comments:

Note: /5 cm

2023100049

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

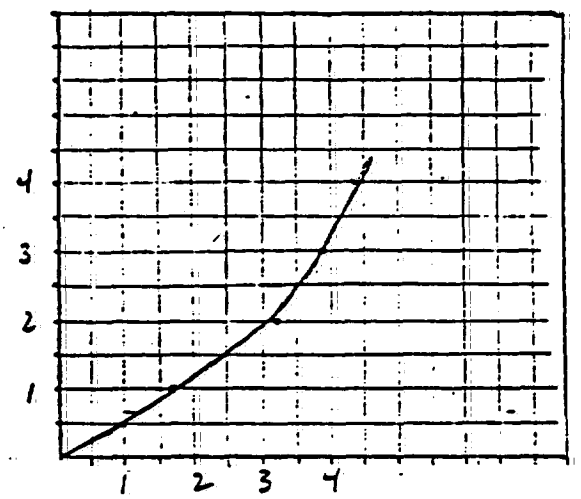
Date 5-31 Time 11:30 Subject # 10 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION 0.5v/div

Pressure	Output voltage
0	0
.5	1.0
1.0	1.7
2.0	3.2
3.0	3.9
4.0	4.3
5.0	4.5
6.0	5.0
7.0	5.3
8.0	5.6
9.0	5.8
10.0	6.0



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
1	Lighting (Bottom)	1.0	0.5	12.5
2		1.1	0.6	15
3		1.1	0.6	15
4		1.1	0.6	15
5		1.2	0.68	17
6	Top	1.1	0.6	15
7		1.0	0.5	12.5
8		1.2	0.68	17
9		1.7	1.0	25
10		1.3	0.75	19
		1.2	0.68	17
		0.9	0.45	11.3

Test comments:

Window / 5mm

$p_L = 12.5$, $p_u = 16.7$, $p_b = 6.5$

$\bar{p} = 16.1$

2023100050

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

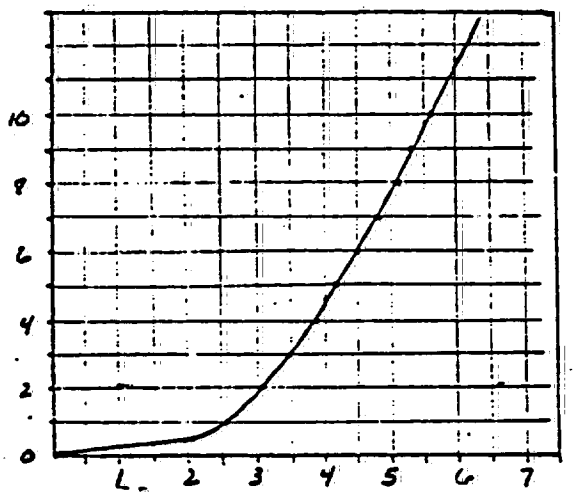
Date 5-31 Time 12:55 Subject # 11 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5v/cm)
0	0
0.5	2.1
1	2.6
2	3.1
3	3.5
4	3.9
5	4.2
6	4.5
7	4.8
8	5.1
9	5.3
10	5.6



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
1	Lighting (bottom)	0.8	0.15	3.8
2		1.0	0.17	4.3
3		0.6	0.10	2.5
4	Change scale 0.2V/div	1.3	0.08	2
5		2.5	0.17	4.3
6	Top	3.0	0.20	5.0
7		4.5	0.4	10.0
8		5.2	0.5	12.5
9		7.5	1.9	47.5
10	0.5 V/div	4.2	5	125
		4.0	4.3	108

Test comments:

$p_L = 3.7$, $p_L = 3.3$ $p_u = 5.3$ $\bar{p} =$

2023100051

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

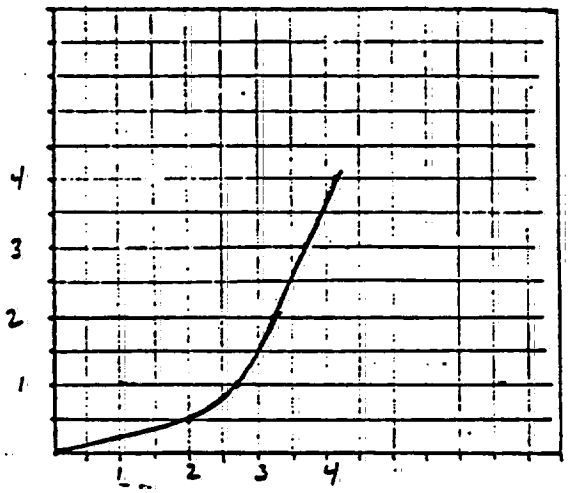
Date 5-31 Time 1:40 Subject # 12 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5 v/cm)
0	0
0.5	2.0
1	2.7
2	3.2
3	3.7
4	4.1
5	4.4
6	4.8
7	5.1
8	5.4
9	5.7
10	6.0



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
1	Lighting (Bottom)	1.2	0.3	7.5
2		3.2	2	50
3		1.5	0.4	10
4		2.2	0.6	15
5	Top	1.8	0.5	12.5
6		2.9	1.3	33
7		1.8	0.5	12.5
8		1.9	0.55	13.8
9				
10				

$p_L = 7.5$, $p_u = 18.0$, $p_b = 25$, $\bar{p} = 21.5$

Test comments:

Window Shade

2023100052

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

PRESSURE MEASURING TESTS

SERIES B-BARCLAY

Brown and Williamson Tobacco Co.
1600 W. Hill St.
Louisville, Ky. 40201

Consultant's report prepared by

Roger D. Kamm, Ph.D.
Massachusetts Institute of Technology
Cambridge, MA. 02139

Sept. 29, 1981

2023100053

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Lip-Pressure Measuring Tests - Series B - Barclay

A second series of tests were conducted to measure the pressure exerted on a cigarette filter by human lips. The purpose of these tests (Series B) was to determine the pressure exerted on a Barclay filter, as opposed to the filter of a Rich Light which was tested in the first series (Series A).

In essence, the measurement method and test procedure were the same as in Series A, with the exceptions noted in Appendix A. A small water-filled bulb attached to the cigarette filter at the position of lip contact experiences a rise in internal pressure when exposed to the pressure acting exterr to the bulb. This pressure rise is measured by a low compliance pressure transducer and displayed on an oscilliscope.

The relationship between pressure applied to the bulb by a smoker's lips and the magnitude of the oscilliscope-trace deflection is calibrated using a device which simulates the action of human lips. The device employs a thin-walled latex tube which applies a variable (but measurable) level of pressure to the cigarette filter by means of inflation of the tube with air pressure. When the cigarette is being smoked we convert the oscilliscope reading to pressure, using this calibration relationship, to obtain a measure of lip-pressure.

The smokers were selected from a group of individuals who had previously served as panelists at the test facility operated by Brown & Williamson. Each was asked to smoke normally using a fresh Barclay

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

cigarette instrumented as described above. The oscilliscope trace deflection produced with each puff was recorded by my collegue, Mark Johnson, seated in the same room as the smoker, and later converted to pressure using the calibration relationship. Typically ten puffs were recorded; five with the bulb positioned against the upper-lip, five with the bulb against the lower-lip. Whether the upper- or lower-lip was tested first was selected randomly during the two days of testing.

The test results were analysed in the same fashion as before yielding values for each smoker for: pressure exerted during lighting, p_L; average upper-lip pressure, p_u; and average lower-lip pressure, p_b. Overall averages (and standard deviation) were computed from the entire group of 17 subjects and an overall mean lip-pressure, $\bar{p}$ was determined. The results are given in Table 1. All test data sheets are included in Appendix B.

It should be pointed out that in these tests, as in Series A, we encountered some problem in positioning the bulb so that it made good contact with the smoker's lips. At times during the test, it was apparent that the bulb was not against the lip. All such readings were disregarded. At other times, a low reading was observed, probably as a result of the bulb being near the inner or outer edge of the lip contact area. Since there was no consistent means of discriminating between these low measurements and those which were closer to the maximum lip-pressure, they were necessarily included in the analysis. The results therefore reflect an average of the pressure distribution along the lips, not a maximum.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Judging from the distribution of readings obtained, however, it is clear that the maximum lip-pressure for any given individual is not more than about twice as large as the average values given in Table 1.

These results compare favorably with the measurements made during the first test series using Rich Lights:

Series A	Series B
p_L = 55.0 torr	25.1
p_u = 43.7	45.1
p_b = 24.7	28.8
$\bar{p}$ = 34.2	35.2

Clearly there are no significant differences between the pressures exerted on the Rich Light and Barclay filters and therefore, all conclusions drawn from Series A still apply. Most importantly, the pressures exerted by human lips on the Barclay filter are most closely approximated by the Cambridge holder, currently used in the FTC test procedure. The filtrona holder, by contrast, exerts pressures which are about 15 times greater than normal lip-pressure.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Table 1. Data Summary

Lip-pressures (in torr)

Subject	Upper-lip (p_u)	Bottom-lip (p_b)	Overall ($\bar{p}$)	Lighting (p_L)
1	7.9	18.8	14.0	(a)
2	(calibration error)			
3	7.0	6.7	6.8	(a)
4	59.5	4.8	32.1	6.4 (b)
5	4.4	3.5	4.0	2.54 (b)
6	27.5	2.1	14.8	(a)
7	124	144	133	135 (c)
8	10.7	37.5	22.6	(a)
9	9.5	2.6	5.7	1.0 (b)
10	14.9	6.7	9.7	4.1 (b)
11	51.8	1.5	26.6	(a)
12	(bulb rupture)			
13	(bulb rupture)			
14	54.0	22.4	35.1	20.3 (b)
15	63.5	115	82.9	57.1 (c)
16	57.5	31.5	44.6	(a)
17	138	31.6	80.5	7.6 (b)
18	97.4	27.9	54.0	5.1 (b)
19	7.0	6.8	6.9	12.7 (c)
Average ± s.d.	45.8 ± 43.1	29.0 ± 41.4	35.8 ± 36.1	25.1 ± 41.9

(a) Bulb not against lip

(b) Lighting with bulb against bottom-lip

(c) Lighting with bulb against upper-lip

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Appendix A

Modifications in the Apparatus and Test Procedure

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

In the Series A tests, mounting the delicate sensing bulb onto the filter was found to be extremely time-consuming. Furthermore, mounting the bulb to the cigarette was a difficult task requiring a steady hand and no doubt contributed to some slight inconsistencies from one cigarette to the next.

To eliminate these problems in Series B the bulb was instead mounted on a 5/16" I.D. latex sleeve which could be easily mounted and, more importantly, re-used for several tests. It was also hoped that using the same sleeve would eliminate the need for separate calibrations on each cigarette. This proved not to be true, however, probably due to the influence on sensitivity of very slight differences in the placement of the latex sleeve on the filter.

In using the sleeve, we felt that there was no compelling reason to remove a portion of the filter paper as had been done in Series A prior to attaching the bulb. Since the filter paper represents a more rigid backing than the fibrous filter and yields less when load is applied, not removing the paper would tend to produce higher readings. In that the pressure levels in Series A and B are not significantly different, this appears to be a relatively minor effect.

We modified the test procedure in only one important respect. Due to the tendency of the channels in the Barclay filter to collapse and remain collapsed when subjected to the high calibration pressure, the calibration was conducted at the <u>end</u> of each test in Series B rather than at the beginning as in Series A. It was reasoned that, if the Barclay filter was altered in

2023100059

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

a systematic fashion prior to smoking, that this might lead to changes in the smoker's normal draw and, hence, his or her normal lip-pressure.

In all other respects, the test apparatus and procedure were the same as described in the Series A Final Report.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Appendix B

Test Results

2023100061

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

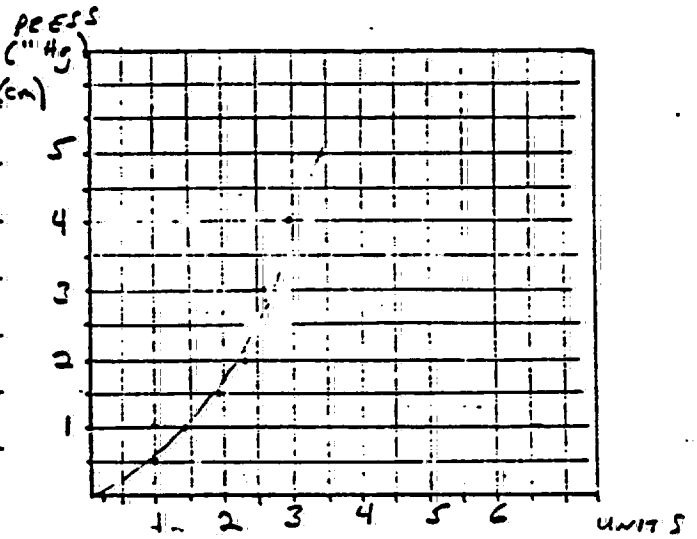
Date 8/31 Time 9:30 AM Subject # 1 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (1.5v/cm) (cm)
0	0.2
0.5	1.0
1.0	1.4
1.5	1.9
2.0	2.3
3.0	2.6
4.0	2.9
5.0	3.4
6.0	3.6
7.0	3.8
8.0	4.0
9.0	4.2
10.0	4.5



TEST RESULTS

	Measurement #	Maximum scale reading		Photograph
UP	1 LIGHTING	.4	0	0
	2	1.2	0.8	0.45
	3	0.9	0.5	0.20
	4	1.0	0.6	0.25
	5	1.1	0.7	0.35
BOTTOM	6	1.6	1.2	0.7
	7	1.8	1.4	1.0
	8	1.1	0.7	0.35
	9	1.9	1.5	1.1
	10	1.4	1.0	0.55

215 ± 4.6

Test comments: CIGARETTE TO FAR INTO MOUTH (SHE SAID) ZERO WAS ABOUT 0.4 WHILE SHE HELD CIGARETTE

2023100062

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

no calibration

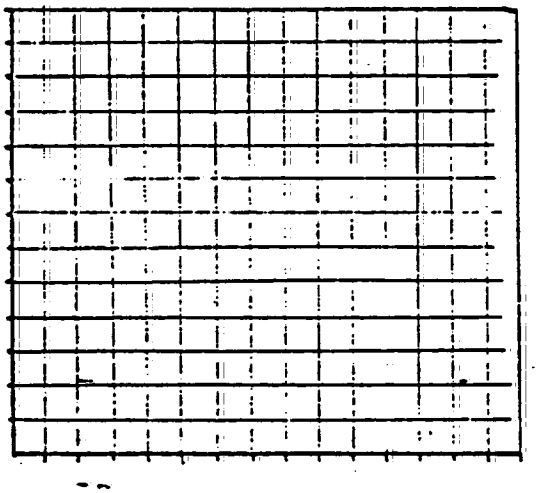
Date 8/31 Time 10:00 Subject # 2 Sex F

Weight _____ Height ____

Comments SHE REALLY SUCKED HARD IN THE BEGINNING (BOTH CHEEKS WENT IN)

CALIBRATION SAME AS #1

Pressure	Output voltage



TEST RESULTS

	Measurement #	Maximum scale reading	Photograph
LIGHTING UP	1	4.2	
	2	9.0	
	3	8.5	
	4	7.1	
POISON	5	7.2	
	6	0.6	
	7	3.3	
	8	2.4	
	9		
	10		

Test comments:

BASELINE 0.5

CALIBRATION WAS ASSUMED NOT TO HAVE CHANGED FROM #1; THIS MAY HAVE BEEN A BAD ASSUMPTION

2023100063

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

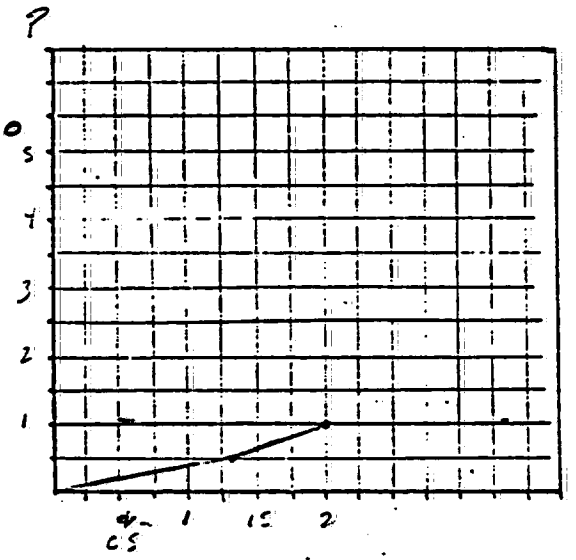
Date 8/31 Time (10:45) 10:30 Subject # 3 Sex F

Weight — Height —

Comments

CALIBRATION

Pressure (in. Hg)	Output voltage (0.5v/cm)
0	~~[illegible]~~ 0.0
0.5	~~[illegible]~~ 1.3
1.0	2.0
1.5	2.8
2.0	3.3
3.0	4.3
4.0	4.9
5.0	5.4



TEST RESULTS

	Measurement #	Maximum scale reading	Photograph	
LIGHTING TOP	1	0.5	~~0.2~~	0.05
	2	0.8	~~0.25~~	0.15
	3	1.3	~~0.5~~	0.4
	4	1.3	~~0.5~~	0.4
	5	0.75	~~0.3~~	0.15
BOTTOM	6	1.0	~~0.4~~	0.25
	7	1.0	~~0.4~~	0.25
	8	0.8	~~0.35~~	0.2
	9	1.1	~~0.45~~	0.35
	10			

Test comments:

BASELINE 0.4

BASELINE 0.3

CALIBRATION DONE WITH CIGARETTE AFTER TEST

2023100064

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

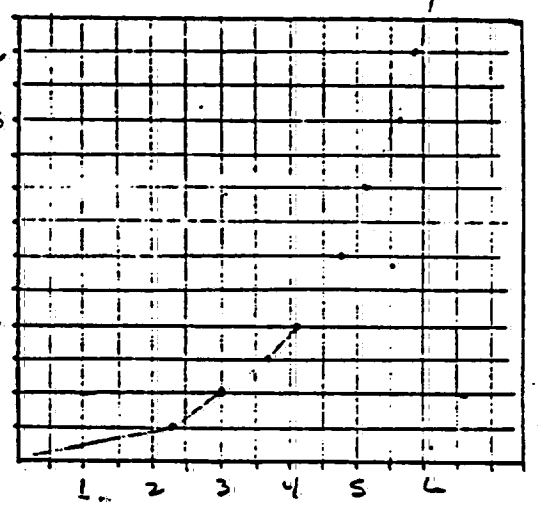
Date 8/21 Time 11:15 Subject # 4 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5V/cm)	Redo
0.0	(0.7)	(0.1)
0.5	2.6	2.4
1.0	3.3	3.0
1.5	3.9	3.7
2.0	4.4	4.1
3.0	5.2	4.8
4.0	5.7	5.1
5.0	6.0	5.6
6.0	6.4	5.8
7.0		6.1
TEST RESULTS 8.0		6.3



	Measurement #	Maximum scale reading	Photograph	
BOTTOM	1 LIGHTING	1.2	0.3	0.25
	2	1.0	0.25	0.20
	3	1.0	0.25	0.20
	4	0.7	0.2	0.10
TOP	5	2.1	0.4	0.35
	6	6.5	8.0	8.0
	7	2.0	0.4	0.35
	8	2.8	0.8	0.65
	9			
	10			

Test comments:

BASELINE AFTER PROBES DISCONNECTED
0.2

CALIBRATION DONE AFTER TEST

2023100065

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

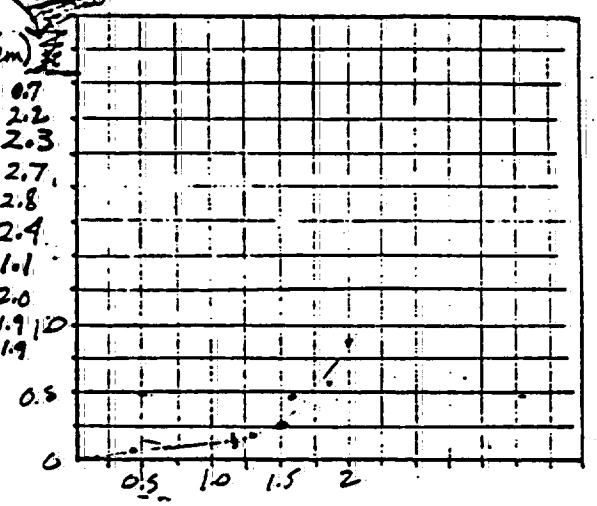
Date 4 Time 12 Subject # 5 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in. Hg)	Output voltage (in. H_2O)	(0.5v/cm) (cm)
0.0	0.0 (IN. Hg)	0.4 0.7
0.5	3.4	1.2 2.2
1.0	6.8 (.45)	2.3
	11.1 (.82)	2.7
1.5	13.0 (.96)	2.8
	7.2 (.53)	2.4
	1.0 (.07)	1.1
	2.9 (.21)	2.0
	2.3 (.17)	1.9
	2.0 (.15)	1.9



TEST RESULTS

	Measurement #		Maximum scale reading	Photograph
BOTTOM	1	LIGHTING	0.7	0.10
	2		1.0	0.15
	3		0.9	0.15
	4		1.0	0.15
TOP	5		1.5	0.25
	6		1.1	0.15
	7		1.0	0.15
	8		1.0	0.15
	9			
	10			

Test comments:

BASELINE WHEN HOLDING CIGARETTE

0.3

CALIBRATION DONE AFTER TEST (CIGARETTE FILTER WAS MASHED DOWN BY SMOKER)

2023100066

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

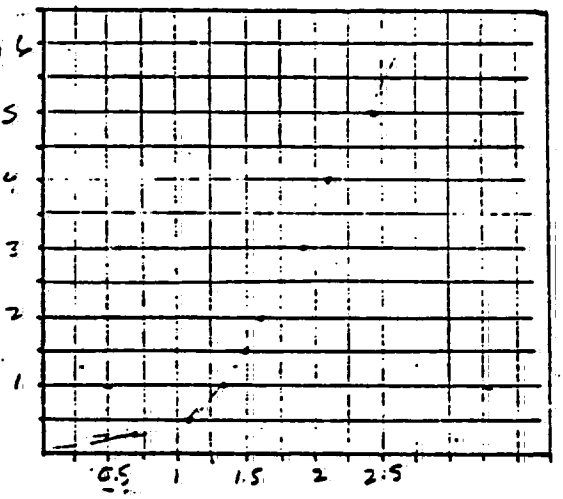
Date 8/31 Time 1:50 Subject # 6 Sex F

Weight _____ Height _____

Comments NEW BULB ; IT IS A LITTLE FLATTER

CALIBRATION

Pressure in Hg	Output voltage (0.5v/cm)
0.0	0.1
0.5	1.2
0.25	0.8
1.0	1.4
1.5	1.6
2.0	1.7
3.0	2.0
4.0	2.2
5.0	2.5
6.0	2.6



TEST RESULTS

	Measurement #		Maximum scale reading	Photograph
BOTTOM	1	LIGHTING	0.3	0
	2		0.4	0.05
	3		0.8	~~0.10~~ 0.08
	4		1.0	0.12
	5		0.8	0.08
BTOP	6		0.8	0
	7		1.0	0.08
	8		2.2	1.25
	9		2.5	2.0
	10		2.0	1.0

Test comments:

BASELINE 0.3 BASELINE 0.6 BASELINE 0.8

CALIBRATION DONE AFTER TEST

2023100067

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

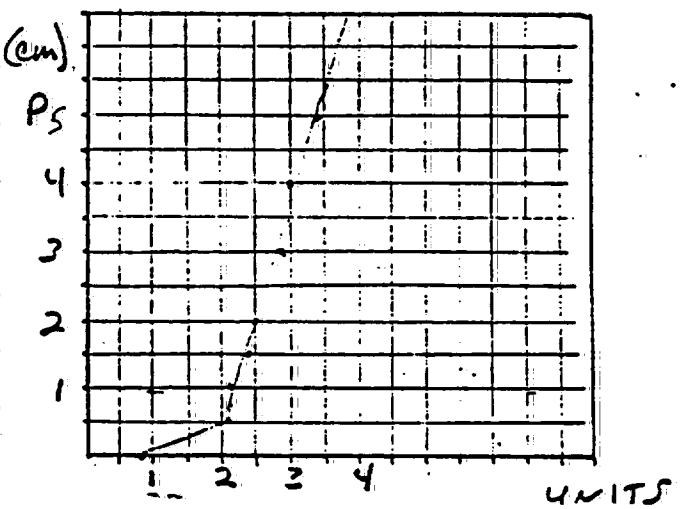
Date 8/31 Time 2:30 Subject # 7 Sex M

Weight — Height —

Comments

CALIBRATION

Pressure (IN ~~Hg~~)	Output voltage (0.5v/cm)
0.0	0.9
0.5	2.1
1.0	2.2
1.5	2.4
2.0	2.5
3.0	2.8
4.0	3.0
~~5.0~~	~~3.4~~
6.0	3.7
7.0	4.0



TEST RESULTS

	Measurement #		Maximum scale reading	Photograph
TOP	1	LIGHTING	3.0	5.3
	2		2.5	3.7
	3		2.0	2.0
	4		3.2	~~4.4~~ 6.0
	5		3.0	5.3
	6		3.5	7.0
BOTTOM	7		3.1	6.025
	8		3.1	6.025
	9		2.6	4.1
	10		3.3	6.5
			3.0	5.3

Test comments:

BASELINE DURING SMOKING 0.4

CALIBRATION DONE AFTER TEST

2023100068

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

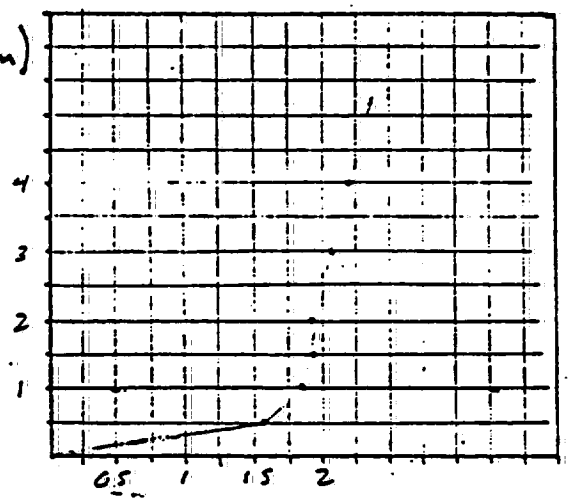
Date 8/21 Time 3:45 Subject # 8 Sex M

Weight _____ Height _____

Comments CIGARETTE SEEMED TO COMPRESS A LITTLE DURING CALIBRATIO

CALIBRATION

Pressure (N/Hg)	Output voltage (0.5v/cm)	(cm)
0.0	1.7	0
0.5	3.3	1.6
1.0	3.5	1.8
1.5	3.6	1.9
2.0	3.6	1.9
3.0	3.8	2.1
4.0	3.9	2.2
5.0	4.0	2.3



TEST RESULTS

	Measurement #	Maximum scale reading		Photograph
TOP	1	2.2	1.3	0.4
	2	2.2	1.3	0.4
	3	1.9	1.0	0.3
	4	2.4	1.5	0.5
	5	2.4	1.5	0.5
BOTTOM	6	3.2	1.0	0.3
	7	4.2	2.0	2.3
	8	4.2	2.0	2.3
	9	4.2	1.9	1.0
	10			

Test comments:

BASELINE 0.9 CAFEINE 2.2 CAFEINE 2.4

CALIBRATE AFTER TEST

2023100069

Test Data Sheet

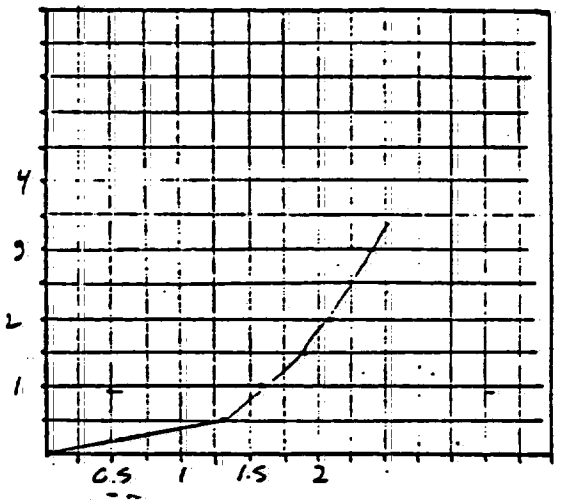
Date 8/21 Time 5:00 Subject # 9 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure	Output voltage	
0	.1	0
.5	1.4	1.3
1.0	1.7	1.6
1.5	2.0	1.9
2.0	2.2	2.1
3.0	2.5	2.4
4.0	2.7	2.6



TEST RESULTS

	Measurement #		Maximum scale reading		Photograph
BOTTOM	1	LIGHTING	0.2	0.1	0.04
	2		0.3	0.2	0.08
	3		0.3	0.2	0.08
	4		0.6	0.5	0.20
	5		0.4	0.3	0.12
TOP	6		0.8	0.7	0.28
	7		1.4	1.3	0.5
	8		1.0	0.9	0.36
	9		1.0	0.9	0.36
	10				

Test comments:

BASELINE DURING TEST

0.1

2023100070

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

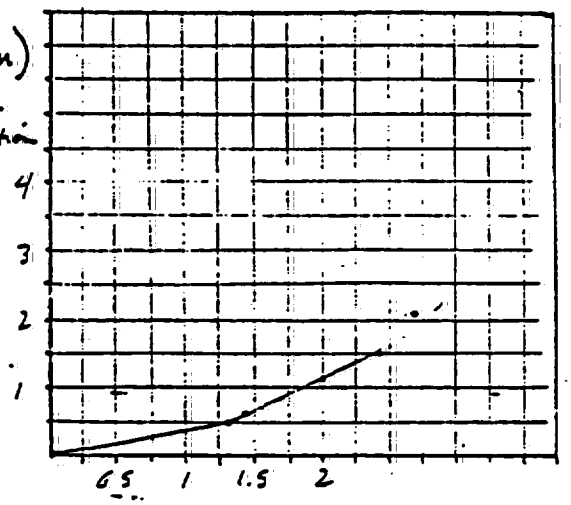
Date 9/1 Time 9:15 Subject # 10 Sex M

Weight _____ Height _____

Comments STILL USING SAME BULB FROM LAST NIGHT

CALIBRATION

Pressure (IN Hg)	Output voltage (0.5v/cm) (cm)
0.0	0.0 (0.1) ← After Calibration
0.5	1.3
0.6	1.4
1.1	2.0
1.5	2.4
2.1	2.7
2.4	2.8
2.8	2.9
6.0	3.7



TEST RESULTS

	Measurement #		Maximum scale reading		Photograph
BOTTOM	1	LIGHTING	0.5	0.4	0.16
	2		0.2	0.1	0.04
	3		0.3	0.2	0.08
	4		1.4	1.2	0.45
	5		0.5	0.4	0.16
	6		1.65	1.55	0.7
TOP	7		1.6	1.6	0.75
	8		1.6	1.7	0.8
	9		0.7	0.9	0.32
CALIBRATION DONE AFTER TEST	10		0.8	0.9	0.36

Test comments:

BASELINE 0.1

BASELINE 0.0

BASELINE -0.1

2023100071

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

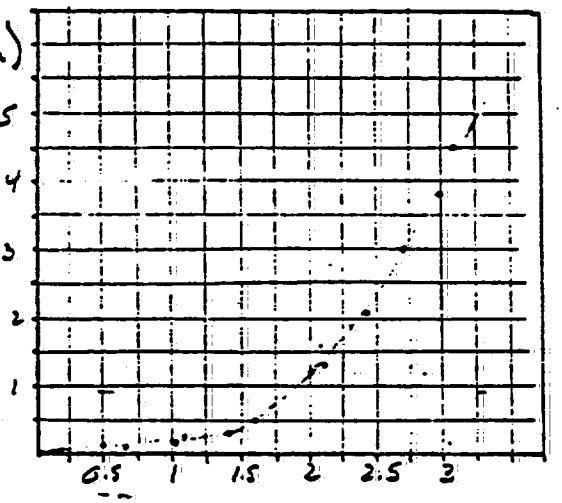
Date 9/1 Time 10:00 Subject # 11 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure in Hg	Output voltage (0.5V/cm)	(cm)
0.0	0.3	0
0.3	1.7	1.4
0.2	1.4	1.1
0.1	1.3	1.0
0.05	1.0	0.7
~~[illegible]~~		
1.3	2.4	2.1
1.2	2.3	2.0
0.5	1.9	1.6
2.1	2.7	2.4
3.0	3.0	2.7
4.5	3.4	3.1
3.8	3.3	3.0



TEST RESULTS

	Measurement #		Maximum scale reading		Photograph
TOP	1	LIGHTING →	0.2	0	0
	2		2.5	2.3	1.9
	3		2.0	1.8	0.8
	4		3.2	3.0	3.9
	5		2.4	2.2	1.55
BOTTOM	6		0.7	0.5	0.05
	7		1.3	0.9	0.08
	8		1.0	0.6	0.055
	9		0.8	0.4	0.045
	10				

CALIBRATION DONE AFTER TEST

Test comments:

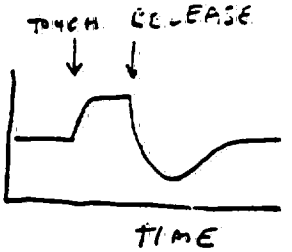
LIGHTING 0.2 [illegible] 0.4

2023100072

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

X
burnt tube

Test Data Sheet



Date 9/1 Time 10:30 Subject # 12 Sex F

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (IN Hg)	Output voltage (0.5v/cm) (cm)
0.0	0.0 (0.4) Tube touching
0.3	1.2
0.2	1.0
0.1	0.8
1.7	1.3
1.3	1.3
0.6	1.2
0.3	1.0
1.2	1.3

without suction

Peaked out at 1.3 cm, even at 12 in Hg

TEST RESULTS

	Measurement #	Maximum scale reading	Photograph
BOTTOM	1 LIGHTING	1.0	
	2	1.6	
	3	2.2	
	4	1.5	
	5	0.5	
	6	0.5	
TOP	7	1.6	
	8	CIGARETTE BURNED TUBING	
CALIBRATION DONE AT TOP	9	RESPONSE CURVE	
	10	TO TOUCHING TUBE	

Test comments:

0.0

Tube rupture, probably from calibration pressure at burned section of tubing

2023100073

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Apriori, decided not to incl in data set because participated in previous test (WITH ROGE

Date 9/1 Time 11:15 Subject # X Sex M

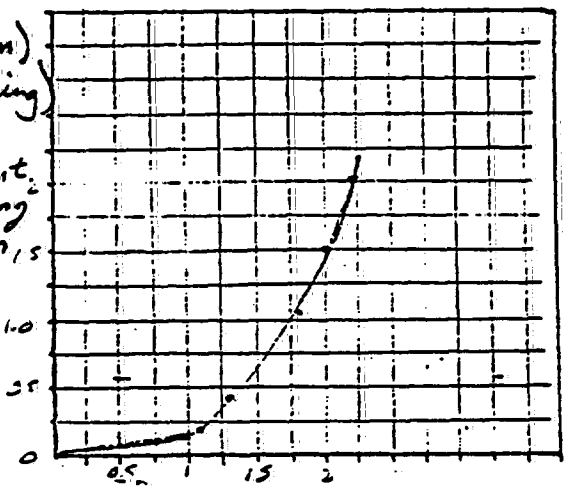
Weight _____ Height _____

Comments NEED TO FIND OUT SUBJECT # FROM FIRST TEST SET

CALIBRATION

Pressure (in. wg)	Output voltage (0.5v/cm)	(cm)
0.0	0	0.2 (0.4 touching)
0.4	1.3	1.5
0.2	1.1	1.3
1.05	1.8	2.0
1.5	2.0	2.2
2.0	2.2	2.4
2.6	2.4	2.6

without sucking down



Here get continuous drift down - probably insert and take in black box test.

Prior calibration points OK.

TEST RESULTS

	Measurement #		Maximum scale reading		Photograph
TOP	1	LIGHTING	2.1	2.1	1.7
	2		1.8	1.8	1.65
	3		0.9	0.9	0.75
	4		1.2	1.2	0.30
	5		1.7	1.7	0.95
BOTTOM	6		0.5	0.3	0.1
	7		0.5	0.3	0.1
	8		0.5	0.3	0.1
	9		0.4	0.1	0.05
	10		0.5	0.2	0.05

CALIBRATION DONE AFTER TEST

Test comments:

BASELINE 0.2 BASELINE 0.0

2023100074

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date 9/1 Time 11:45 Subject # 13 Sex F

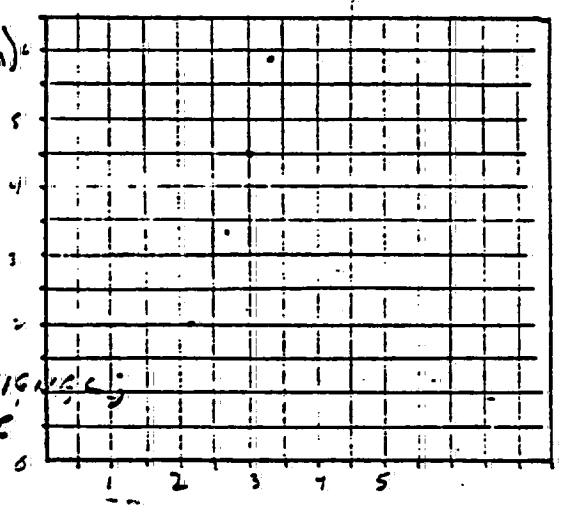
Weight _____ Height _____

Comments SHE REALLY CLAMPS DOWN!
Teeth definitely on bulb

CALIBRATION

Pressure (In Hg)	Output voltage (0.5v/cm) (cm)
0.0	0.0
0.1	0.2
0.6	1.6
1.1	1.7
2.0	2.1
3.3	2.7
4.5	3.0
5.9	3.3

LOST CALIBRATION SIGNAL
SEEMS TO BE BULB RUPTURE



TEST RESULTS

	Measurement #	Maximum scale reading		Photograph
UP	1 LIGHTING	4.5	4.5	
	2	4.5	4.5	
	3	4.0	4.0	
	4	3.5		
	5	3.5		
BOTTOM	6	1.1		
	7	4.0		
	8	4.0		
CALIBRATION DONE AFTER TEST	9	1.0		
	10			

Test comments:

BASELINE 0.0 BASELINE 0.3

2023100075

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date 9/1 Time 12:40 Subject # 14 Sex F

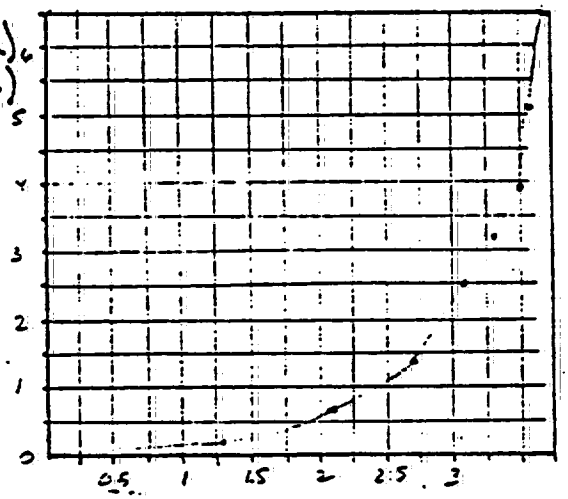
Weight _____ Height _____

Comments NEW BULB

CALIBRATION

Pressure In Hg	Output voltage (0.5v/cm) (cm)
0.0	0.0 (0.3 Touching)
0.2	1.3
0.65	2.1
1.4	2.7
2.5	3.1
2.2	3.3
3.9	3.5
5.1	3.6
6.4	3.8

without suction



TEST RESULTS

	Measurement #		Maximum scale reading		Photograph
BOTTOM	1	LIGHTING	2.4	2.3	0.8
	2		2.1	2.3	0.6
	3		2.5	2.6	1.0
	4		2.5	2.4	1.0
	5		2.6	2.4	1.1
TOP	6		2.9	2.5	1.6
	7		3.2	2.8	2.5
	8		2.7	3.1	1.2
CALIBRATION AFTER TEST	9		3.4	2.6	3.2
	10			3.3	

Test comments:

BASELINE 0.1 BASELINE

2023100076

Test Data Sheet

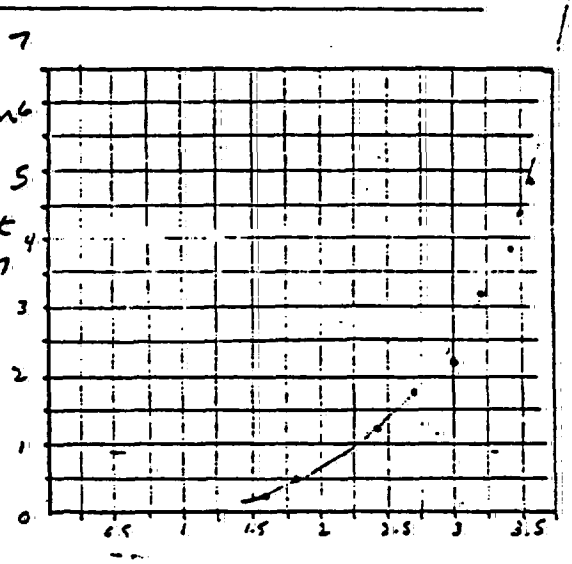
Date 9/1 Time 1:30 Subject # 15 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (in Hg)	Output voltage (0.5V/cm)
0.0	0.0 (0.7)
0.5	1.8
0.25	1.6
1.2	2.4 without suctioning
1.75	2.7
2.2	3.0
2.7	3.2
3.2	3.4
4.4	3.5
4.8	3.6
5.3	3.6
6.2	3.7
7.6	3.9
8.5	4.0
9.5	4.1
10.7	4.1



TEST RESULTS

Measurement #		Maximum scale reading		Photograph
TOP 1	LIGHTING	3.0	2.9	2.25
2		3.0	2.9	2.25
3		3.4	3.3	3.5
4		3.0	2.9	2.25
5		3.0	2.9	2.25
BOTTOM 6		3.4	3.3	3.5
7		3.9	3.8	7.0
8		3.3	3.2	3.1
9				
CALIBRATION AFTER TEST 10				

Test comments:

0.1

2023100077

Test Data Sheet

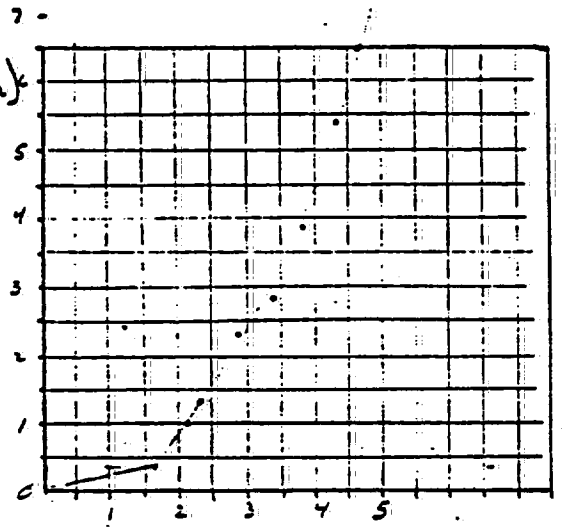
Date 9/1 Time 3:10 Subject # 17 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (In Hg)	Output voltage (0.5v/cm)	(cm)
0.0	-0.1 (0.0)	0
1.0	2.0	2.1
0.3	1.5	1.6
1.3	2.2	2.3
2.3	2.8	2.9
2.8	3.3	3.4
3.9	3.7	3.8
5.4	4.2	4.3
6.5	4.6	4.7
7.5	4.8	4.9



TEST RESULTS

	Measurement #		Maximum scale reading	Photograph
BOTTOM	1	LIGHTING	1.3	6.3
	2		1.3	6.3
	3		1.3	6.3
	4		0.9	6.2
	5		2.6	1.7
	6		2.4	1.4
	7		4.0	4.5
TOP	8		3.2	2.7
	9		4.0	4.5
CALIBRATE AFTER TEST	10		4.8	7.0
			4.6	6.4
			4.6	6.4
			4.4	5.5

Test comments:

BASELINE

0.0

2023100078

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date 9/1 Time 3:45 Subject # 18 Sex F

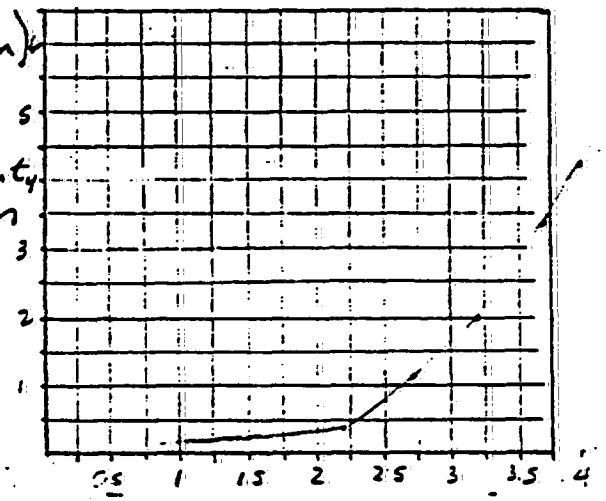
Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (In Hg)	Output voltage (0.5v/cm)	
0.0	0	0.8 (0.8)
0.4	2.2	2.3
1.1	2.7	2.8
2.0	3.2	3.3
3.3	3.7	3.8
4.2	4.0	4.1
4.6	4.1	4.2
5.6	4.3	4.4
6.4	4.5	4.6
7.9	4.7	4.8

without suction



TEST RESULTS

	Measurement #		Maximum scale reading		Photograph
BOTTOM	1	LIGHTING	1.6	1.3	0.2
	2		2.0	2.7	1.1
	3		2.5	2.2	0.4
	4		4.0	3.7	3.3
	5		2.6	2.3	0.5
TOP	6		4.0	3.7	3.3
	7		4.2	3.9	4.1
	8		4.2	3.9	4.1
CALIBRATION AFTER TEST	9				
	10				

Test comments:

BASELINE

0.3

2023100079

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

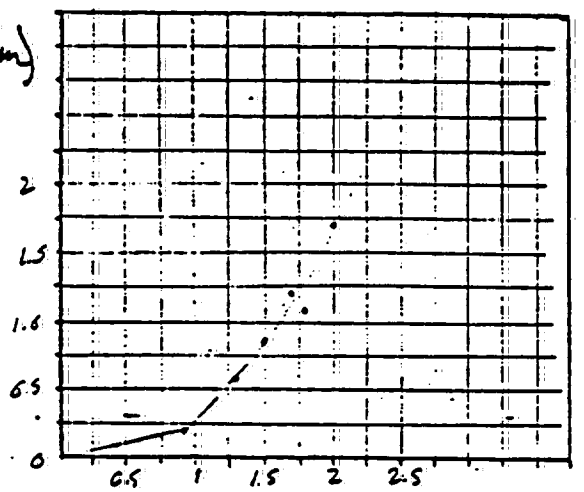
Date 9/1 Time 4:25 Subject # 19 Sex M

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure (In Hg)	Output voltage (0.5v/cm) (cm)
0.0	0.0
0.2	0.9
0.6	1.3
1.2	1.7
1.8	2.0
~~2.9~~	2.6
1.1	1.8
0.85	1.5



TEST RESULTS

	Measurement #	Maximum scale reading		Photograph
TOP	1 LIGHTING	1.4	1.2	0.5
	2	0.8	0.6	0.25
	3	0.6	0.4	0.2
	4	0.5	0.3	0.18
	5	0.8	0.6	0.25
BOTTOM	6	1.0	0.8	0.3
	7	0.8	0.6	0.25
	8	1.2	0.8	0.3
	9	0.9	0.5	0.22
CALIBRATE AFTER TEST	10			

Test comments:

BASELINE 0.2

BASELINE 0.4

2023100080

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

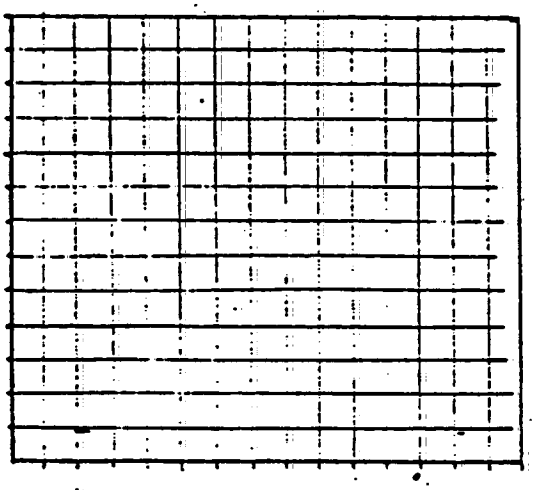
Date 9/1 Time 5:30 Subject # FILTERONA Sex _____

Weight _____ Height _____

Comments SUCTION, THEN INSERT, THEN RELEASE SUCTION.

CALIBRATION

Pressure	Output voltage
0	.1 (0.8)
1.3	3.9
.85	3.3
2.5	4.5
3.5	4.9



TEST RESULTS

Measurement #	Maximum scale reading	Photograph
1	5.1	
2	5.0	
3	4.7	
4	4.9	
5		
6		
7		
8		
9		
10		

Test comments: WRONG TUBING! ON FILTERONA HOLDER

2023100081

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date 9/1 Time 2:30 Subject # BORGWALDT Sex _____

Weight _____ Height _____

Comments INSERT ALL THE WAY THROUGH, THEN SLOWLY PULL BACK

CALIBRATION

Pressure In Hg	Output voltage
0.0	0.0 (0.3 inch)
0.3	0.9
0.2	0.7
0.75	1.0 without suction
1.1	1.1
1.9	1.1
2.4	1.2
2.8	1.25
3.3	1.3
3.6	1.35
4.0	1.35
4.9	1.4

TEST RESULTS

Measurement #		Maximum scale reading	Photograph
6.0	1.4		
8.3	1.45		
10.2	1.5		
11.2	1.5 first pass	1.3	
2		1.2	USE
3		1.2	PEAK
4		1.3	OF
5		1.3	EACH
6		1.2	RUN
7	second pass	1.2	
8		1.3	
9		1.2	
10		1.3	
	third pass (cigarette rotated)	1.3	
		1.4	
		1.4	
		1.45	
		1.4	

CALIBRATE AFTER TEST

Test comments:

NOTE: VALVE TO SYRINGE WAS OPEN (BUT NOT TO ATMOSPHE THIS WAS CAUSE OF LOWERED SENSITIVITY!

2023100082

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date 8/21 Time 4:30 Subject # CAMB. #1 Sex _____

Weight _____ Height _____

Comments BULB FLATTENED OUT DURING CALIBRATION

CALIBRATION

Pressure (IN Hg)	Output voltage (0.5v/cm) (cm)
0.0	0.1
0.5	0.8
1.0	1.0
1.5	1.1
2.0	1.2
2.5	1.3
3.0	1.3
3.5	1.4
4.0	1.5
5.0	1.6
6.0	1.5
7.0	

TEST RESULTS

Measurement #	Maximum scale reading	Photograph
1 CAMBRIDGE	1.5	
2	1.6	
3	1.4	
4	1.4	
5	1.3	
6	1.6	
7	1.6	
8	1.7	
9	1.7	
10		

CALIBRATE AFTER TEST

Test comments: PUSHING CIGARETTE INTO HOLDER (TO GET READING)

2023100083

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date 8/31 Time 5:30 Subject #CAMB #2 Sex _____

Weight FILTER HOLDER Height _____

Comments PUSHING CIGARETTE INTO HOLDER (TO GET READING)

CALIBRATION base .3 v

Pressure	Output voltage
0	.3
.5	1.4
1.0	1.6
1.5	1.8
2.0	2.0
2.25	2.3
4.1	2.5
5.2	2.6
6.5	2.8
8.1	3.1
10.1	3.3
11.3	3.4
12.1	3.5

TEST RESULTS

Measurement #	Maximum scale reading	Photograph
1	3.0	
2	3.2	
3	3.4	
4	3.3	
5	3.5	
6		
7		
8		
9		
10		

CALIBRATE AFTER TEST

Test comments: CHANGED TO NEW BULB BEFORE THIS TEST

2023100084

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

CAMBRIDGE

Date 8/31 Time 6:00 Subject #3 Sex _____

Weight _____ Height _____

Comments _____

CALIBRATION

Pressure	Output voltage
0	.1
.4	.3
1.4	1.0
2.2	1.4
3.4	1.9
4.5	2.3
6.2	2.6

TEST RESULTS

Measurement #	Maximum scale reading	Photograph
1	2.2	
2	2.0	
3	2.0	
4	2.2	
5		
6		
7		
8		
9		
10		

CALIBRATE AFTER TEST

Test comments: ALL THE WAY IN, BUT TAKE VALUE @ THE RING, NOT THE MAXIMUM WHICH OCCURS ALL THE WAY IN

2023100085

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Test Data Sheet

Date _____ Time 6:30 Subject # FILTERONA Sex _____

Weight _____ Height _____

Comments _____

_____

CALIBRATION

Pressure	Output voltage
0	.2
1.1	1.6
1.9	2.1
4.1	2.7
5.9	3.0
9.3	3.4
10.6	3.5
12.1	3.6
15.0	3.7
19.0	3.8
21.2	3.9
24.6	4.0

TEST RESULTS

Measurement #	Maximum scale reading	Photograph
1	3.8	
2	3.9	
3	* 3.8	
4		
5		
6		
7		
8		
9		
10		

CALIBRATE AFTER TEST

Test comments: * LOST CONNECTION; RECONNECT (UNDER WATER) BEFORE THIS READING.

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BROWN & WILLIAMSON TOBACCO CORPORATION
RESEARCH SERVICES DEPARTMENT

RESTRICTED

EVALUATION OF THE KAMM HOLDER FOR EFFECTS ON VENTILATION, TAR AND OTHER CIGARETTE SMOKE DELIVERIES

J.F. Nall
August 31, 1983

Introduction and Summary of Test Results

A. Purpose of the Test

In early 1982, Philip Morris, Inc. undertook a study purportedly designed to measure ventilation of Barclay cigarettes in a group of human test subjects. The tests, as well as later tests performed by Philip Morris' "independent" testing laboratory, the U.S. Testing Company, were conducted with an experimental device especially constructed for testing Barclays, the "Puff Parameter Analyzer" ("PPA").

On the basis of these tests Philip Morris concluded -- and argued to the FTC -- that Barclay's ventilation is reduced by 30% in "normal" human smoking. The FTC has endorsed this view in its current litigation against Brown & Williamson.

Two explanations have been advanced for the alleged reduction in ventilation during smoking of Barclays:

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first, that smokers crush Barclay's ventilation channels with their lips, and second, that smokers occlude the ventilation channels, blocking them at the very end of the filter tip with their lips.

Our consultant, Dr. Roger Kamm, has determined that the average pressure exerted by human lips during normal smoking is about 34 torr.* Our consultant, Dr. Louis Fine, has determined, from intra-oral fiber optic viewing of Barclay smokers, that occlusion is more likely to occur at relatively shallow insertion depths.

Based in part on the work of Drs. Fine and Kamm in seeking to devise artificial lips for use in cigarette testing, Dr. Kamm has designed an experimental cigarette holder, fitted with a silicone rubber tubing which, when inflated, replicates the pressure exerted by human lips on a cigarette filter during normal smoking. We have used this holder to perform a series of tests to determine Barclay's ventilation rates and tar, nicotine, and carbon monoxide delivery, at a variety of simulated lip pressures and insertion depths. The pressures and insertion depths used in

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* Kamm, Roger D., "PRESSURE MEASURING TESTS," Communication to Brown & Williamson Tobacco Corporation. In Dr. Kamm's studies he measured pressure in terms of "torr". Brown & Williamson's test equipment measured pressure in terms of millimeters of mercury ("mm Hg"). These measurements are precisely equivalent, however, because one torr is equal to one mm Hg.

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these tests reflect our best understanding of actual human lip pressures and insertion depths in smoking.

The Kamm holder was constructed to permit replication, as closely as possible, of the three parameters considered to be of primary importance in affecting ventilation of Barclay cigarettes: lip pressure, depth of filter insertion in the mouth, and "lip drape". Moreover, the tests we performed with the Kamm holder were designed to present a conservative or "worst case" simulation: lip pressures to 85 and 100 torr, well above the 34 torr average known to exist in human smoking, long insertion length (to 10 mm) to maximize opportunities for channel crushing, and short insertion length (to 4 mm) to maximize opportunities for "lip drape". Insertion depth is defined as the length from the filter end of the cigarette that is inserted in the Kamm holder.

The Kamm holders used in this test were fitted with two different moduli of silicone rubber tubing. The modulus of the tubing determines its relative compliance or stretchiness. By changing the modulus of the tubing in the Kamm holder, it is possible to simulate different degrees of "lip drape." The low modulus tubing is the thinnest walled, most compliant material available, and provides for maximum "lip drape," consistent with the "worst case" design of the test.

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We performed ventilation and smoke delivery tests on Barclay 85 KS cigarettes with the Kamm holder.

A. Ventilation Tests

For purposes of the ventilation study, 12 cigarettes were tested at each of: (a) 15 pressures (0, 15, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 85 and 100 mm of Hg., or torr); (b) 4 insertion depths (4, 6, 8 and 10 mm); and (c) two tubings of different modulus (low and medium) for BARCLAY 85 KS cigarettes. The same cigarette was tested at each level of pressure.

Cigarette ventilation data for individual cigarettes are listed in Appendix A. Averages, standard deviations, and sample sizes appear at the righthand side of Table A1 in each row. A single column (read vertically) within an insertion length is the same cigarette. Differences from initial cigarette ventilation at 0 or atmospheric pressure are similarly summarized in Figure A2. Notably, in the worst possible case -- at the shallowest (4 mm) insertion depth and highest (100 torr) pressure with the low modulus tubing -- the average decrement in ventilation was not 30%, but 14.5%.

At conditions giving the largest decrements in ventilation, the ranges of ventilation values from test cigarette to test cigarette are the greatest. Although the

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cause for this variation is not completely known, it is most likely the result of variations in filter construction and in the axial orientation of the cigarette in the Kamm holder, or of the greater difficulty of sealing the cigarette in the Kamm holder at the relatively shallow insertion depths.

Figures 3-12 grouped the data to examine trends. In these figures, "*" represents the average decrease in cigarette ventilation from its initial reading. The "H" and "L" denote the high and low readings respectively. Figures 11-12 show average changes in ventilation, overlayed for the different insertion length, for each modulus of tubing.* The significant results of these tests are summarized as follows:

1. Cigarette ventilation is most impaired with decreasing insertion length <u>and</u> increasing pressure. (Figures 11 and 12)

2. For the two shallowest insertion lengths used

---

* Regression analyses were applied to the data in Figures 11-12. The regression model that is shown below was selected for regressing pressure (X) on the change in ventilation (Y).

$$Y = A + BX^2 \quad (1)$$

The coefficients (A and B) are listed in Figure 13. In addition, the correlation coefficients, r^2, are provided. A perfect correlation between pressure and change in ventilation yields a correlation coefficient of 1.0. Note that all r^2 are close to 1.0. This indicates the model is a good approximation of the relationship between pressure and change in ventilation.

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in these tests (4 and 6 mm), ventilation decreases more with the low modulus tubing, which simulates maximum "lip drape," than with the medium modulus tubing. (Compare Figures 11 and 12) At the 4 mm depth with maximum (100 torr) pressure with the low modulus tubing, the lowest average rate of ventilation recorded was 71%. However, even at this 4 mm depth, with maximum applied pressure and low modulus tubing, average ventilation rates as high as 86% were recorded. (Figure A1)

3. At the more moderate 8 mm insertion depth, with pressures of 35 torr -- near the average in human smoking -- the average ventilation rate was 85.82%.

4. For both moduli of tubing, test cigarettes inserted to 8 and 10 mm depths yield about the same rates of ventilation across the range of applied pressures. In other words, there is little difference between the 8 and 10 mm insertion depths. (Figures 11, 12)

5. The amount of variation among test cigarettes, in both ventilation and delivery, is most dramatic at the shallowest insertion depths, with the highest applied pressures, especially with the low modulus tubing. (Figures A1, B1)

B. Smoke Delivery Tests

Samples from the same population of BARCLAY KS cigarettes used in the ventilation study were used for smoking

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experiments. Twelve ports were smoked for each of 18 combinations (2 moduli x 3 insertion lengths x 3 pressures) of test variables.* Each 12 port sample was randomized across two smoking machines and different runs. Smoke deliveries at 0 torr (atmospheric pressure) for this population of BARCLAY were previously determined using standard FTC smoke procedures (see Figure 14).

Summary statistics for smoke deliveries are shown in Figures 15-17. All of the smoking data are listed in Appendix B. Procedures for measuring smoke delivery are given in Appendix E. Data in Appendix B for tar, nicotine, filter nicotine, filter efficiency and water are presented in columns representing six "replicates." The values given for each replicate represent an average result for ten cigarettes. Data for carbon monoxide and puffs are presented in Appendix B in columns representing 12 replicates. The values given for each replicate represent an average result for five cigarettes.

Graphs of smoke deliveries by tubing are provided in Figures 18-31.

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* For purposes of the smoking tests, we abandoned the 10 mm insertion depth, which proved to perform much like the 8 mm insertion depth in the ventilation studies. Also, due to time limitations, only 35 torr, 50 torr and 85 torr pressure variables were employed.

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All smoking data were evaluated using a technique called analysis of variance ("ANOVA"). ANOVAs are summarized in Appendix C.* Generally, ANOVAs showed that average differences greater than 0.1 mg/cig. of tar, 0.02 mg/cig. of nicotine, and 0.1 mg/cig. of CO are statistically significant at $\alpha = 0.05$ (95% confidence level). Other tests of statistical significance for ancillary smoking data are provided in Appendix C.

The significant results of the smoke delivery tests are summarized as follows:

1. In the very worst case, applying simulated lip pressures (up to 85 torr) well above the known average (34 torr), and the shallowest possible insertion depth (4 mm), with maximum simulated lip drape (low modulus tubing), the average tar delivery recorded was 1.5 mg. per cigarette. (Figure B1)

2. At the highest applied pressure (85 torr), and shallowest insertion depth (4 mm) with the low modulus tubing, the average nicotine delivery recorded was .18 mg./cg. (Figure B1)

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* ANOVA is a well-recognized statistical method for determining the isolated effect of each specific test variable, and the effects of each possible combination of test variables. See, e.g., B. Ostle, Statistics in Research (Iowa State Univ. Press, 1963).

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3. At the more moderate 8 mm insertion depth, with applied pressures near the human average (35 torr), with the low modulus tubing, average tar delivery was 0.6 mg/cig., while average nicotine delivery was .07 mg/cig.

4. The data showed that, over the range of applied pressures and insertion depths with both moduli of tubing, tar delivery did not increase to levels even approaching those indicated by Philip Morris' work with the puff parameter analyzer. With this test apparatus, we determined that pressure of 175 torr -- more than five times the average pressure in human smokers -- is required to reduce ventilation on a Barclay 30% (i.e., to achieve a 60% ventilation rate). With our test apparatus, we smoked 2 samples of 16 ports each at 175 torr, using insertion depths of 6 and 8 mm and the medium modulus tubing. At the 6 mm insertion depth, the maximum tar delivery recorded was 5.4 mg. The minimum tar delivery recorded at the same insertion depth and pressure was 3.2 mg., while the average was 4.1 mg. (Figure 32)

5. CO deliveries are consistent with tar and nicotine and follow the same trends. (see Appendix C and Figure 16 for more detail).

Data shown below summarize results from all experiments:

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Average Tar Delivery (mg/cig.) and Ventilation Rate (%) at Different Pressures (mm Hg)

Insertion Length (mm)	0 mm		35 mm		50 mm		85 mm	
	Vent	Tar	Vent	Tar	Vent	Tar	Vent	Tar
Low Modulus								
4	85.5	ND*	83.1	0.7	80.4	0.9	73.6	1.5
6	85.3	ND	84.6	0.8	83.5	0.8	78.8	1.5
8	86.2	ND	85.8	0.6	85.4	0.7	83.4	1.0
Medium Modulus								
4	86.8	ND	85.1	0.8	83.8	0.7	78.2	1.3
6	87.1	ND	86.4	0.6	85.8	0.7	83.0	1.1
8	87.7	ND	87.4	0.6	87.1	0.6	86.0	1.0

Medium Modulus, 175 mm Hg

Insertion Length (mm)	Vent	Tar
6	58.9	4.1
8	64.0	2.9

* ND = not determined. At 0 pressure, it was difficult to seal the test cigarettes in the Kamm holder sufficiently to ensure good results in a test for tar delivery. Accordingly, tar values at 0 (atmospheric) pressure were determined by the FTC method, and are set forth in Figure 14.

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TEST APPARATUS

1. Kamm Assembly. Figure 1 shows the Kamm assembly. The parts are described as follows:

a) Kamm Holder. The Kamm Holder is machined from a cast acrylic rod. Dimensions are given in the figure. The stainless pressure tubing is pressed into the acrylic wall and sealed with epoxy glue. The pressure tubing is .040" ID HPLC stainless tubing manufactured by Waters Assoc.

b) Kamm Collar. The Kamm Collar is machined from a cast acrylic rod. Dimensions are given in the figure.

c) Kamm Tubing. Dimensions of the Kamm tubing are given in the figure. The tubing is made of silicone rubber and is manufactured by: Bivona Surgical Instrument Inc., 5700 West 23rd Avenue, Gary, Indiana 46404. Specifications of the tubing are as follows:

Characteristic	Low Modulus	Medium Modulus
Silicone Material (General Electric	SE 5218	SE 845
Durometer (Shore A)	25 ± 5	40 ± 5
Tensile strength (psi)	1000	1200
Tear strength (psi)	100	200
Ultimate elongation (%)	800	800
Tensile Modulus		
at 50% (psi)	55	
100% (psi)	80	120
200% (psi)	110	

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2. Pressure/Ventilation Apparatus. The pressure/ventilation apparatus is shown in Figure 2.

3. Cast Acrylic Rod. 0.625" and 0.875" diameter, AIN Plastics, Inc., 249 E. Sanford Blvd., Mt. Vernon, N.Y. 10550.

4. Pressure Tubing. Stainless steel .040" I.D. for HPLC. Waters Associates, Milford, MA 01757.

5. Smoking Machine. Brewer Automatic Pipetting Machine, Model 60470. Modified to take a 35 cc puff volume of 2 second duration.

6. Pressure Transducer. Model DP103-10, Validyne Engineering Corporation, Northridge, CA 91324

7. Laminar Flow Tubes. 1/4" copper tubing. 1118 mm long. Distance between flow measuring point = 203 mm.

8. Analog to Digital Converter. Data Acquisition System A113. Interactive Structure, Inc., Bala Cynwyd, PA.

9. Microcomputer. Apple II Plus.

10. Gelman Holder, Gelman Sciences, Medical Device Division, 674 S. Wagner Avenue, Ann Arbor, MI 48106.

11. Puff Parameter Analyzer. This device was similar to the device used by Philip Morris in its ventilation tests. The glass envelope is approximately 135 mm long with a uniform diameter of about 90 mm. The opening at the end of the envelope that accommodates the ventilation holder is 14 mm in diameter.

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12. Ventilation Holder. Grip holder fitting for cigarettes manufactured by Filtrona Instruments, England.

13. Pressure Regulator. (To provide air pressure at smoking machine.) Nullmatic 0-100 inches of water. Moore Products Co., Spring House, PA.

EXPERIMENTAL PROCEDURE

The pressure/ventilation apparatus shown in Figure 2 was used to measure the effects on cigarette ventilation of pressure applied to the Kamm holder. Referring to that figure, the Kamm holder (C) is assembled by inserting the Kamm tubing through the plastic cylinder. An air tight seal is made by folding the tubing back and over the rim of the plastic holder. O-rings are slid over the grooves in the holder to insure an air tight seal. The holder/tubing assembly is then inserted into the Kamm collar (B). A Gelman holder (A) is inserted into the other end of the Kamm collar. Photographs of the Kamm assembly are shown in Appendix D.

The ventilation envelope (D) is a Filtrona cigarette holder with dental dam wrapped over each end and sealed with O-rings. The ventilation opening is attached to a pressure transducer (F). The ventilation envelope is attached to the puff parameter analyzer, a glass envelope (E), the other end of which is connected to a pressure transducer (F). A cigarette is inserted through the ventilation envelope and

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into the puff parameter analyzer so that the tipping perforations are positioned inside the ventilation envelope. The filter end of the cigarette is then inserted into the Kamm holder to the designated insertion depth. The entire apparatus is now ready to be used for testing. Photographs of the apparatus are shown in Appendix D.

The testing sequence consisted of the following operation:

1. Take a standard puff (35 cc puff volume, 2.0 second duration) on the unlit cigarette.

2. By use of the calibrated pressure transducers, A/D converters, and Apple computer, record puff duration, puff volume through cigarette tobacco section, puff volume through ventilation holes, total puff volume, and percent ventilation. All tests are carried out on an unlit cigarette. Repeat puffing for a total of three puff cycles.

3. Using attached pressure syringe, apply desired amount of pressure as indicated by mercury manometer. Then repeat Steps 1 and 2 on each cigarette that is tested.

4. Repeat steps 1, 2 and 3, applying pressures at fifteen graduated increments ranging from 0 to 100 mg Hg. (torr).

The pressure transducers used to measure flow are assembled and calibrated as follows:

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Taps are brought out of each of the laminar flow elements, and a Validyne DP103-10 differential pressure transducer is hooked to each. The taps are about 203 mm apart and are the same on both elements. The differential transducers then measure the pressure drop across the 203 mm length of tubing. Since the flow is laminar, this pressure is linearly proportional to the flow through the system.

The transducers are attached to individual carrier/demodulators, giving the ability to adjust both span and zero independently of the vent and tobacco section sides.

The two transducer electrical outputs are attached to two channels of multi-channel A/D converter which are interfaced to an Apple II microcomputer. The computer software is designed to detect puff activity when the vent side signal reaches an operator selectable level for an operator selectable number of data points. When this trigger occurs, both the vent and the tobacco side output are summed separately for the duration of the puff. These operations are performed in machine code for maximum acquisition speed. The raw numbers are then converted into volume readings in a BASIC program.

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The calibration procedure involved the following steps:

1. Set the transducer output so that it is compatible with the input requirements of the A/D converter.

2. Hook the two laminar flow elements in series so that the flow through both is the same.

3. Attach a 50 cc syringe to the combined laminar flow elements so that when the plunger is pressed inward, the resulting positive flow causes positive electrical outputs from the transducers.

4. For each calibration, take a number of volume/flow rate readings ranging from 3 cc to 50 cc. Relate these to the output voltage from the transducers using a standard least square fit.

5. Enter the resulting equation into the BASIC program to convert the transducer output into flow rate readings. We have found that the correlation between puff volume and integrated transducer signal is consistently high (typically >0.97).

6. Confirm the resulting calibration by inserting a cigarette or standard of known ventilation rate and check calibration by using a one port syringe type smoking machine (Brewer automatic pipette) set to a 35 cc/2 sec. puff.

Cigarettes used in this study were taken from regular production at the Macon Branch. They represent

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May 2, 1983 production. The cigarettes were conditioned for at least 24 hours prior to testing.* Insertion length marks were placed on the tipping at 4 mm, 6 mm, 8 mm, and 10 mm from the mouth end. Cigarettes from this population were used for both ventilation experiments and for smoking experiments.

Two standard Phipps & Bird smoking machines and standard B&W smoking procedures were used to measure tar at various holder pressures. Standard methods for tar, carbon monoxide, nicotine, and water determination are given in Appendix E of this report. The combined Kamm assembly and Gelman holder was weighed before and after smoking to obtain TPM values. The smoking machine was modified by bringing compressed air through a precision regulator and then to the machine through small Tygon tubing (1/16" I.D.). Each port was fitted with a pressure source that would allow pressures from 0 to 90 torr. Pressure was measured at the source of the pressure just after the regulators and after the last port connection to be sure that there were no leaks during smoking. Photographs of the smoking machine are shown in Appendix D.

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* It is standard procedure in the tobacco industry, as is recognized by the FTC, to condition cigarettes before performing tests like these. Cigarettes are conditioned by allowing them to sit at 75° Fahrenheit and 60% relative humidity for at least 24 hours prior to testing.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Conclusion

Philip Morris contends that the cigarette ventilation of BARCLAY is reduced to about 60% because of blockage of the grooves by human smokers and that tar delivery is 3-7 mg/cig.

With this apparatus we experimentally determined that a pressure of 175 torr or mm of Hg (3 psi), far exceeding that exerted by human lips, is necessary to obtain a cigarette ventilation of about 60%. We then smoked two samples of 16 ports each at 175 mm of pressure for two insertion lengths (6 mm and 8 mm) and a medium modulus Kamm tubing. Smoking results and cigarette ventilation are shown in Figure 32. At this extreme pressure, tar deliveries increased to 3-4 mg/cig., and nicotine deliveries increased to 0.4-0.5 mg/cig.

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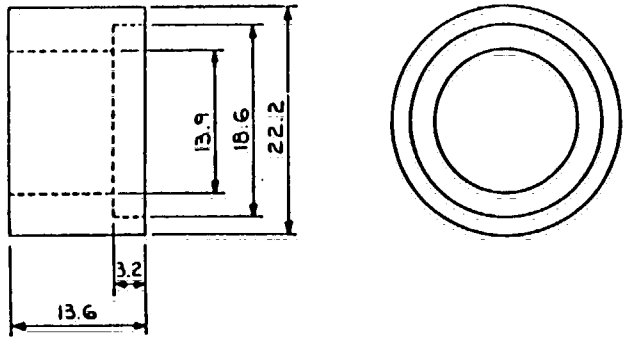
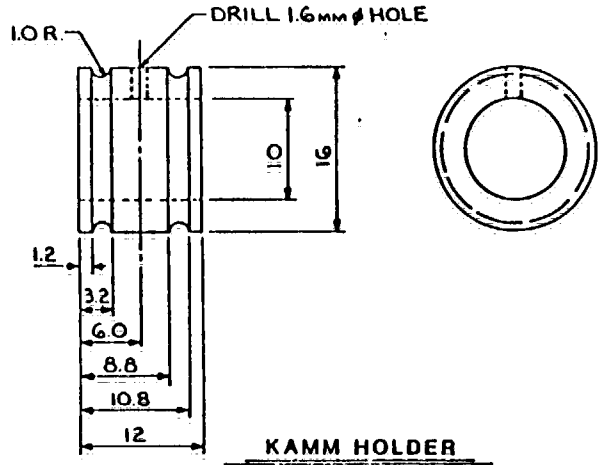
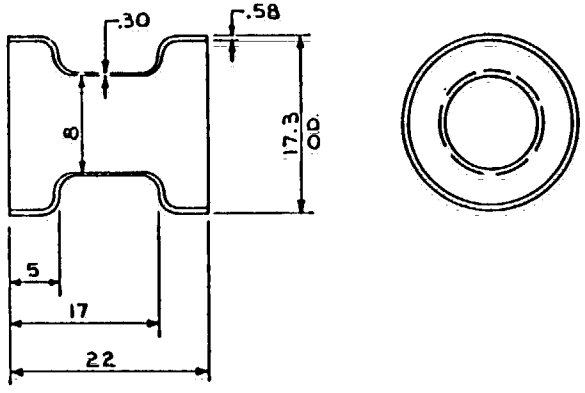
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000



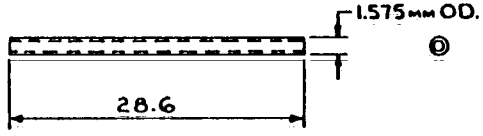
KAMM COLLAR
(CAST ACRYLIC)



KAMM HOLDER
(CAST ACRYLIC)



KAMM TUBE
(SILICONE RUBBER)



PRESSURE TUBE
(16 GA. STAINLESS STEEL TUBING)

NOTE: ALL DIMENSIONS IN MM.

BROWN & WILLIAMSON TOBACCO CORPORATION

DWN. CLARK	TITLE FIGURE 1 KAMM ASSEMBLY
APR'D	
DATE 8-12-83	DWG.
SCALE 1:40	

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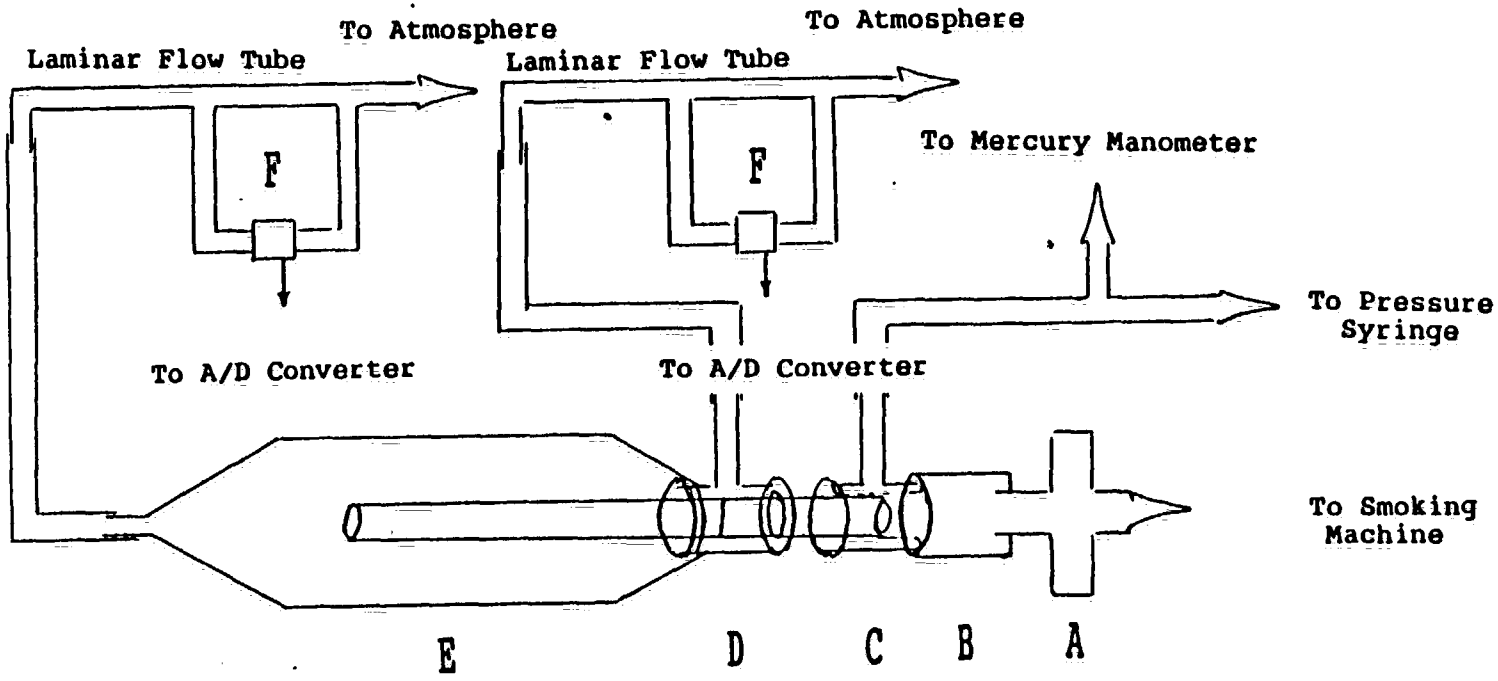
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 2. Pressure/Ventilation Apparatus



A. GELMAN HOLDER

B. COLLAR FOR KAMM HOLDER

C. KAMM HOLDER

D. VENTILATION ENVELOPE

E. GLASS ENVELOPE FOR CIGARETTE

F. PRESSURE TRANSDUCER

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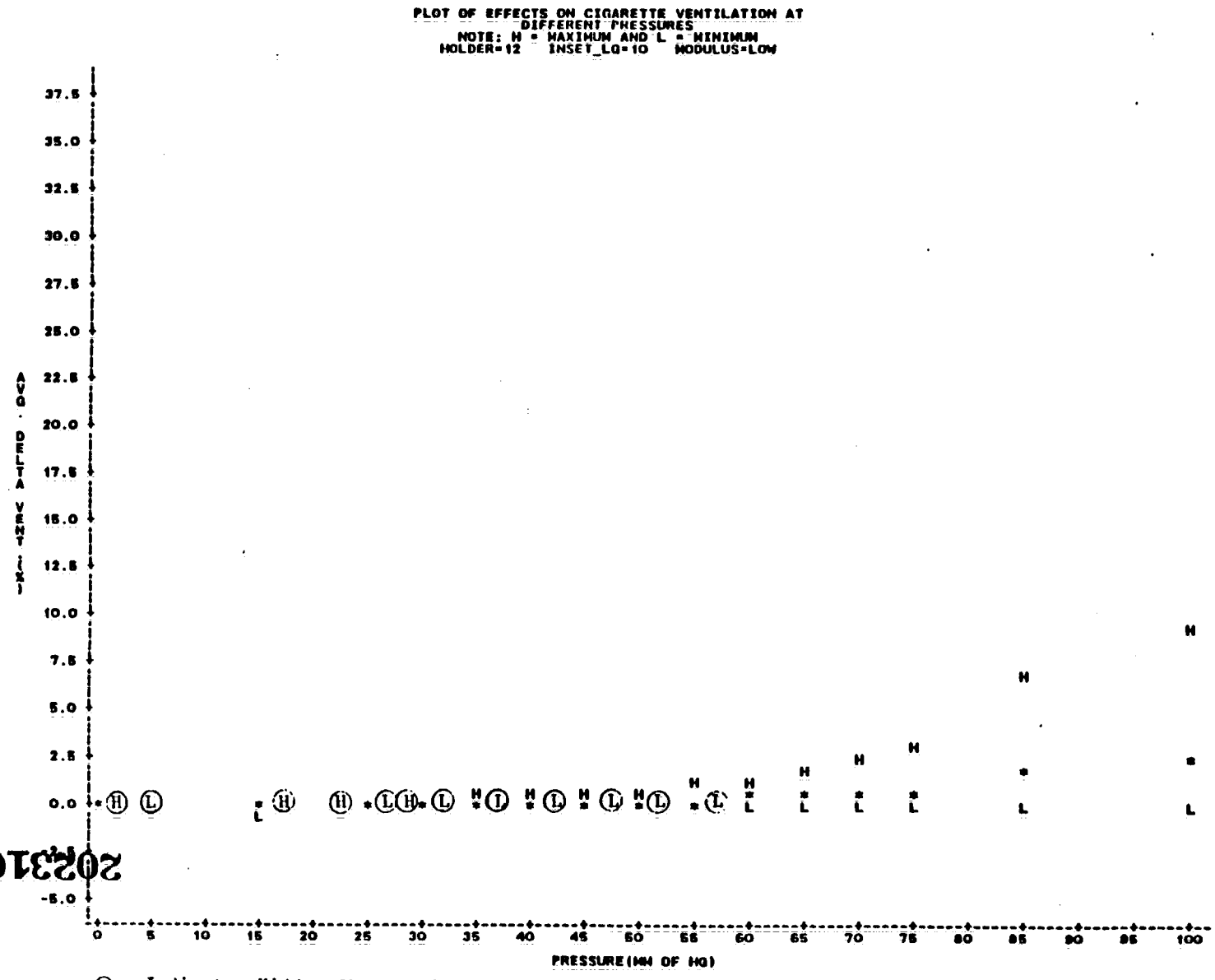
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

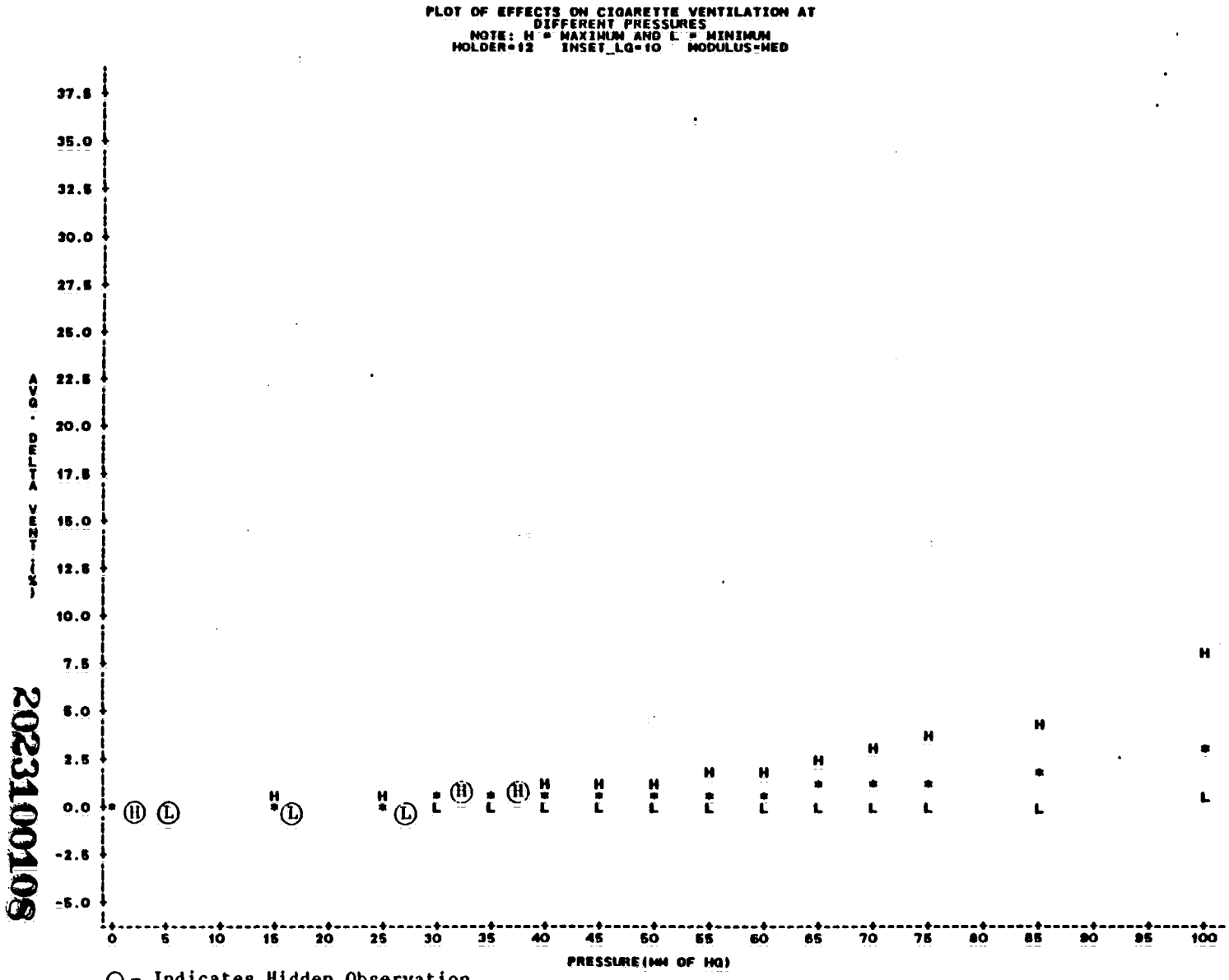
Figure 3



○ - Indicates Hidden Observation

2023100107

Figure 4

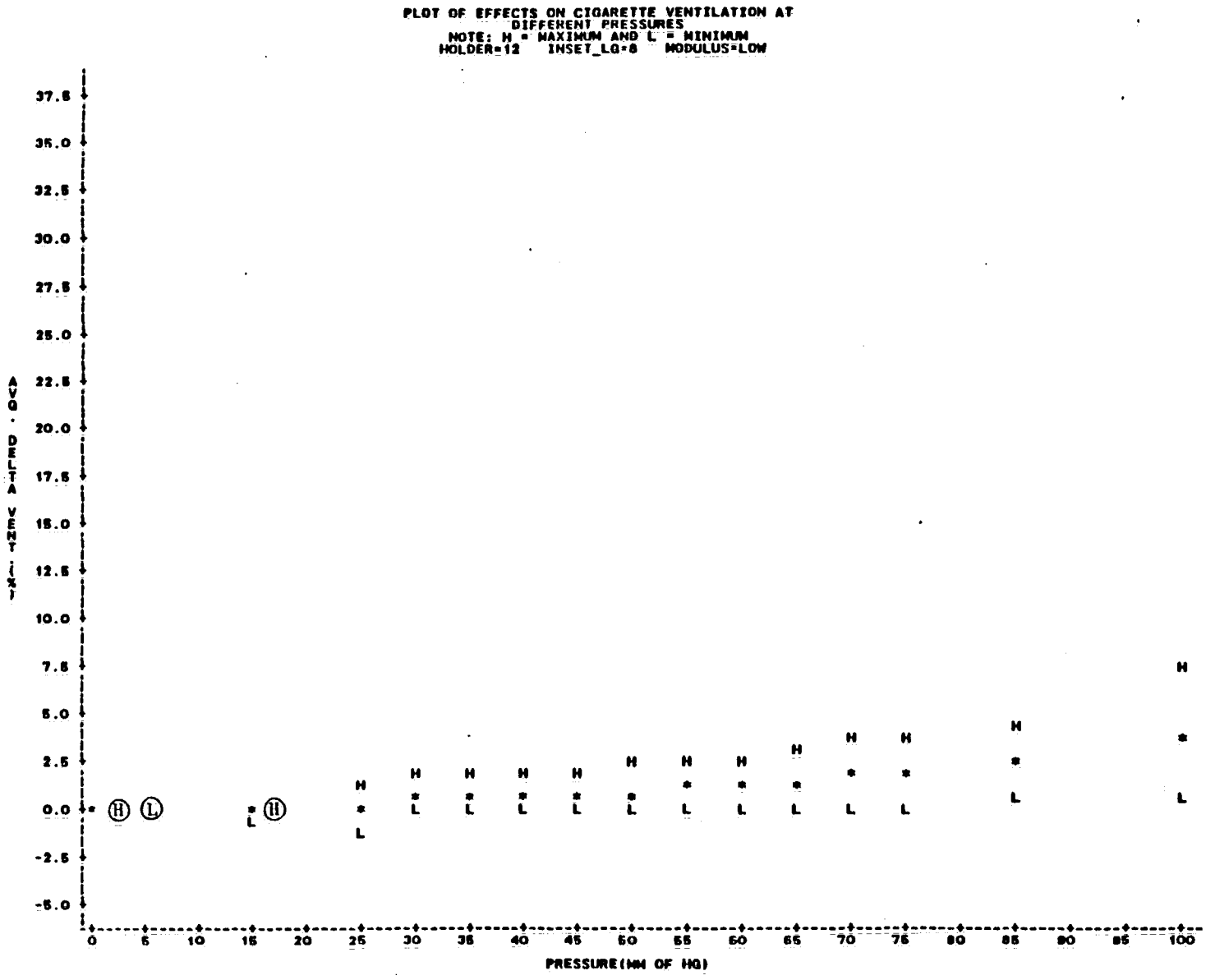


○ - Indicates Hidden Observation

2023100108

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 5

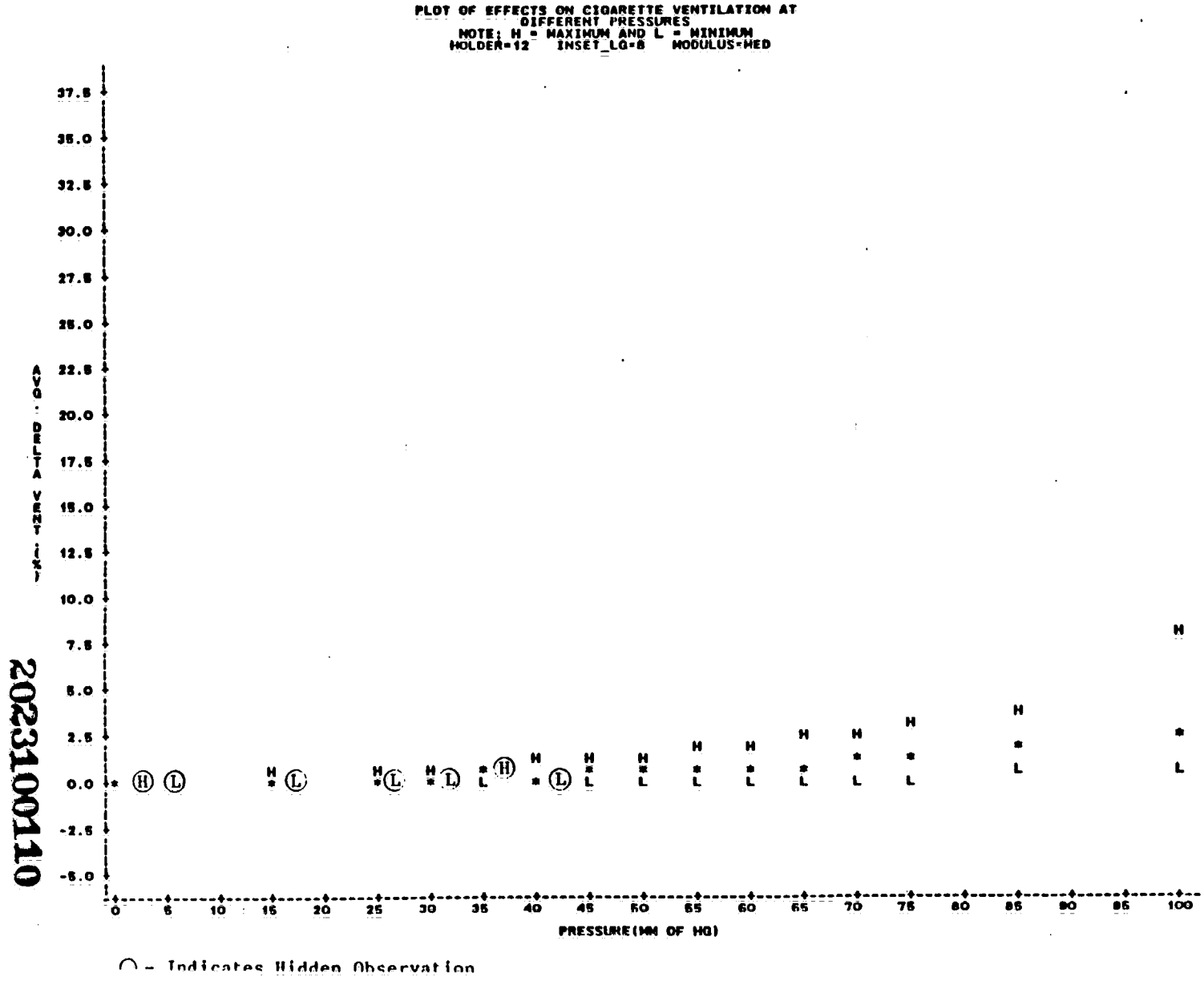


◯ - Indicates Hidden Observation

2023100109

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 6

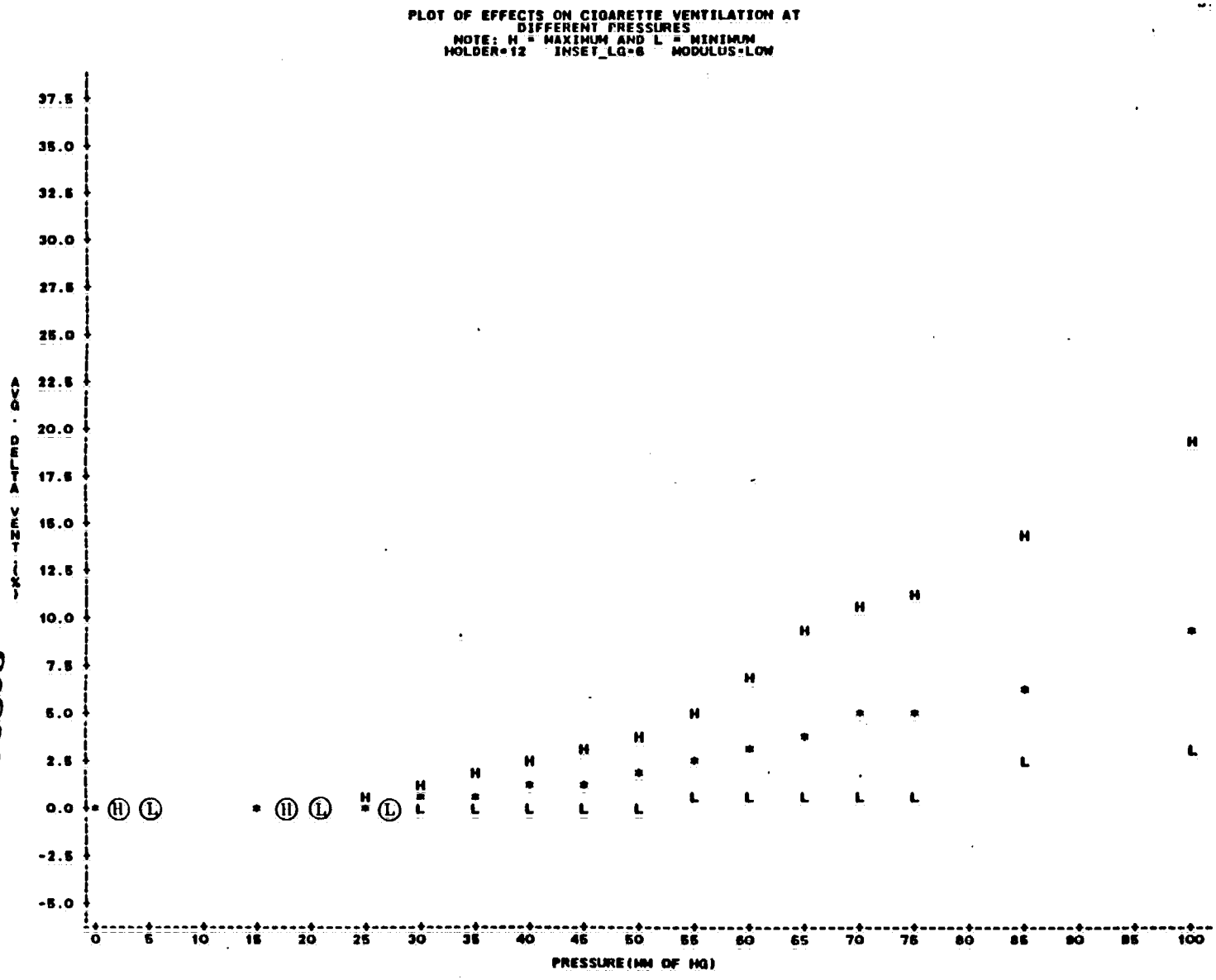


◯ - Indicates Hidden Observation

2023100110

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 7



( ) - Indicates Hidden Observation

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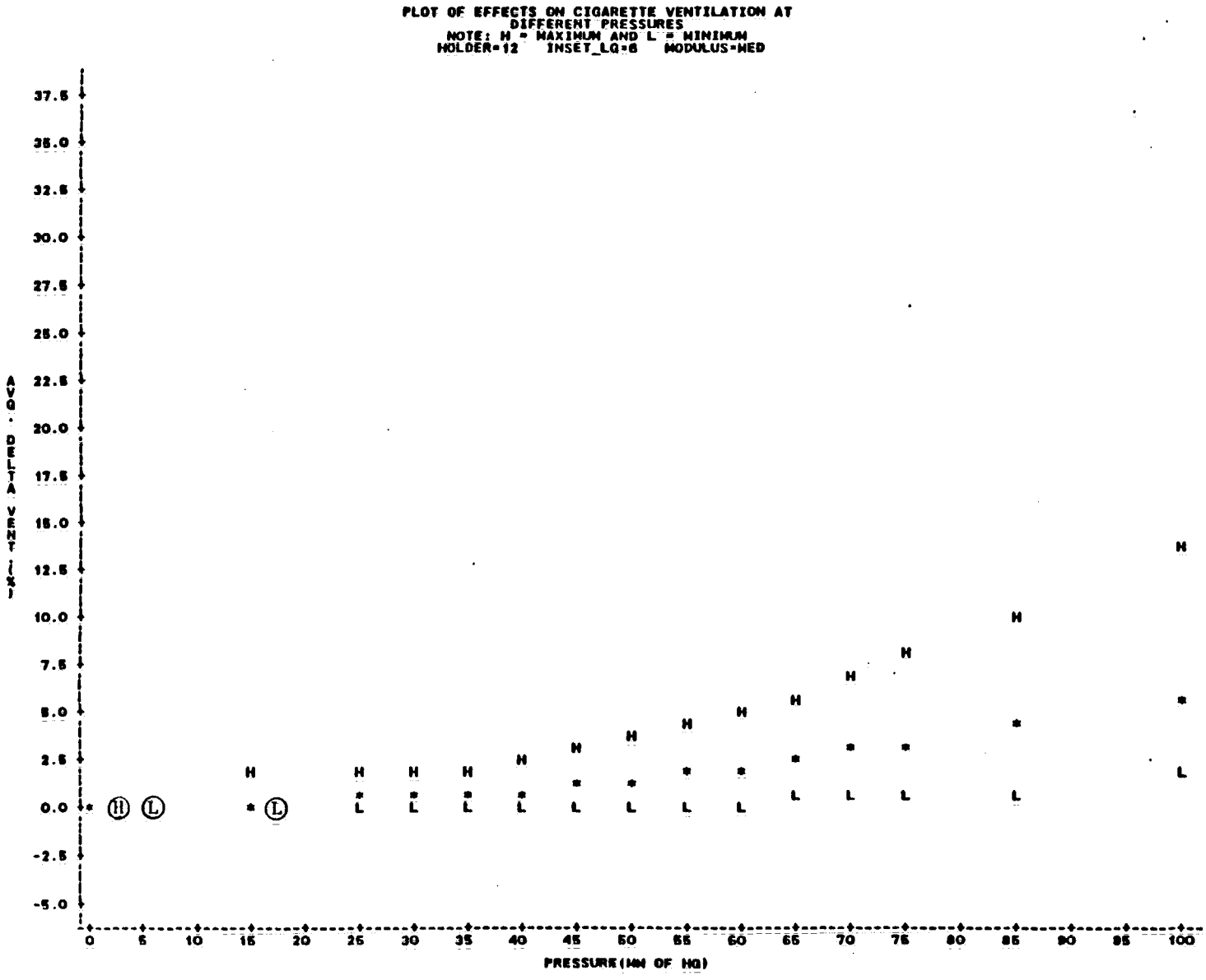
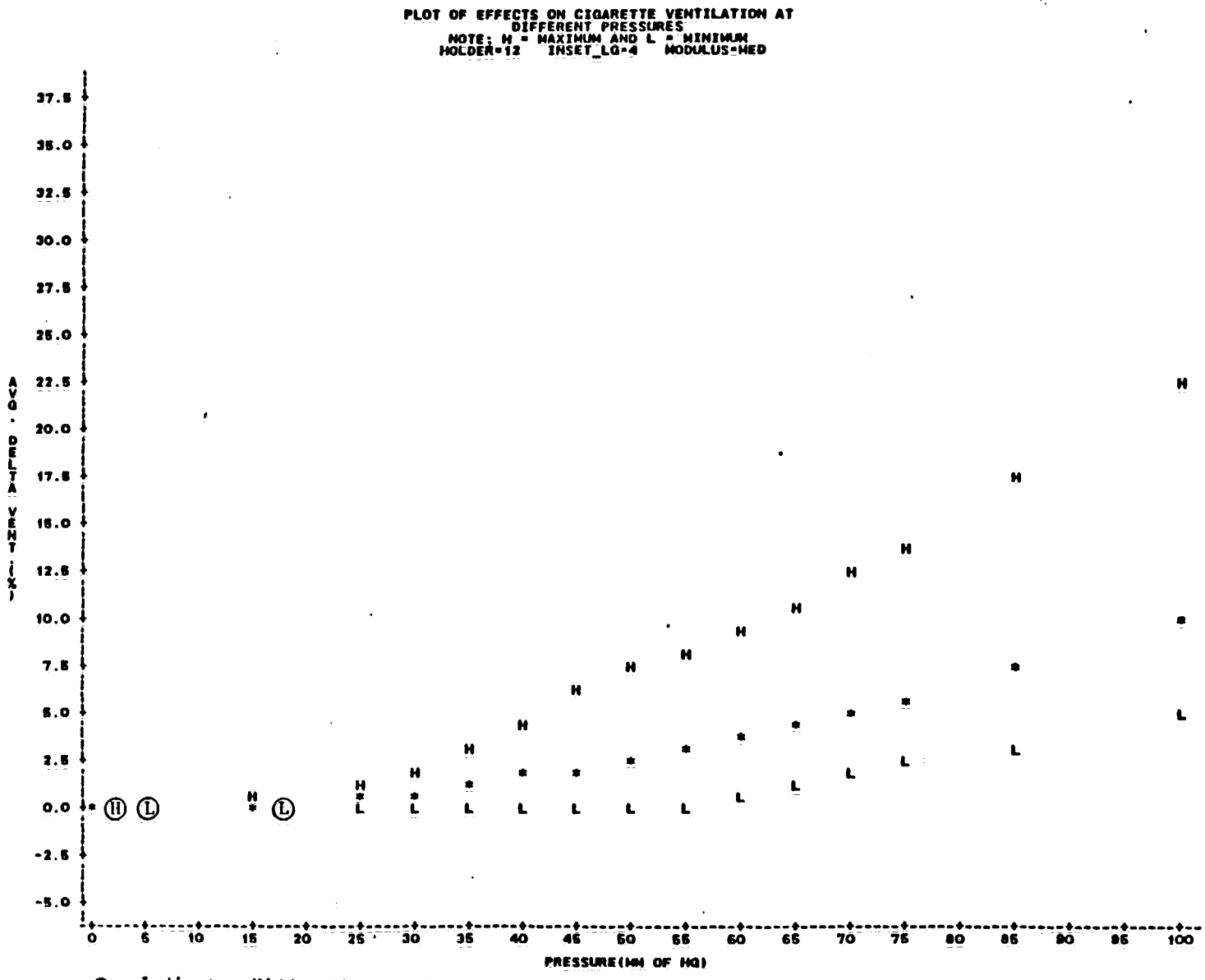
Figure 8



O Indicates Hidden Observation

2023100112

Figure 9

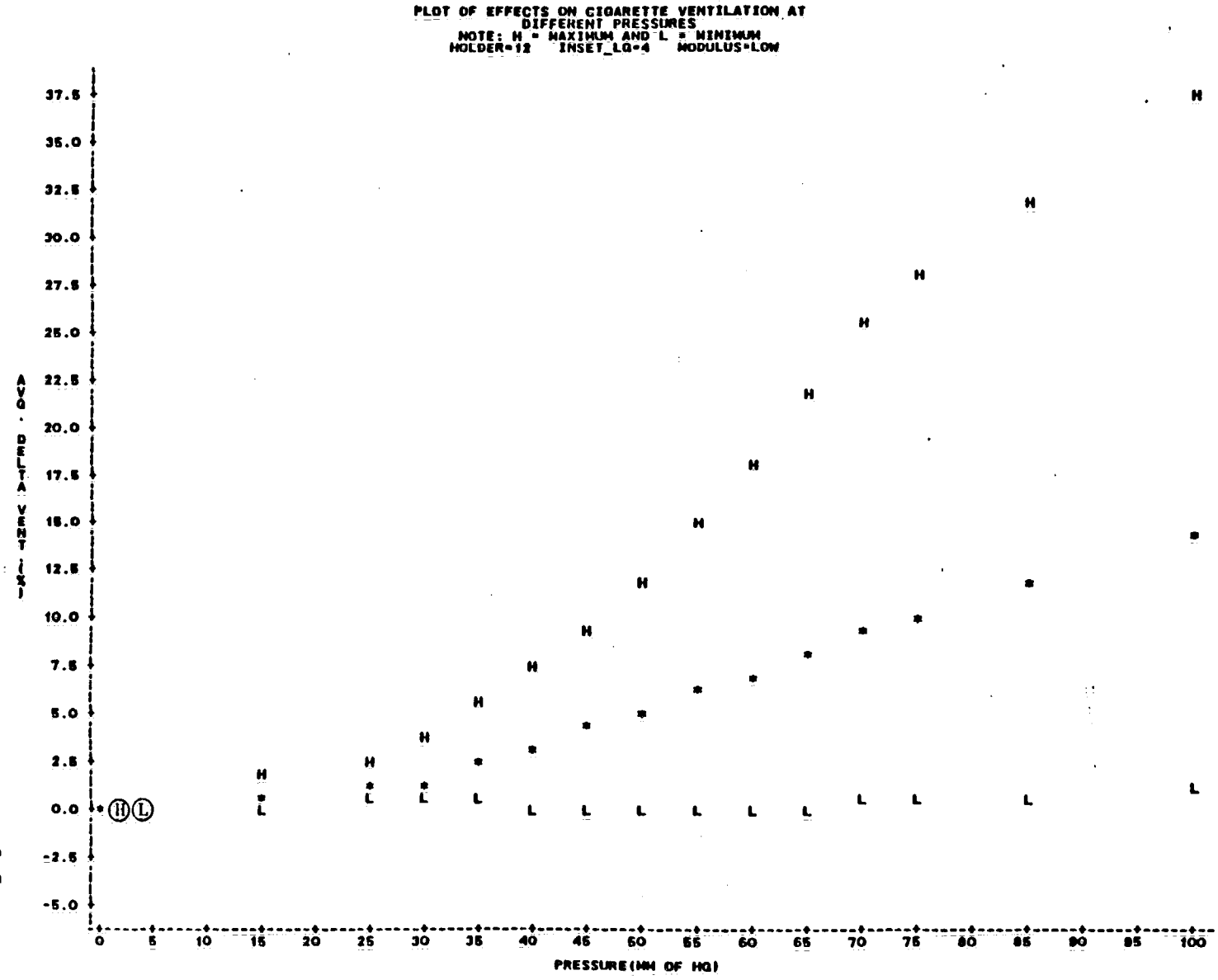


○ - Indicates Hidden Observation

2023100113

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 10



◯ - Indicates Hidden Observation

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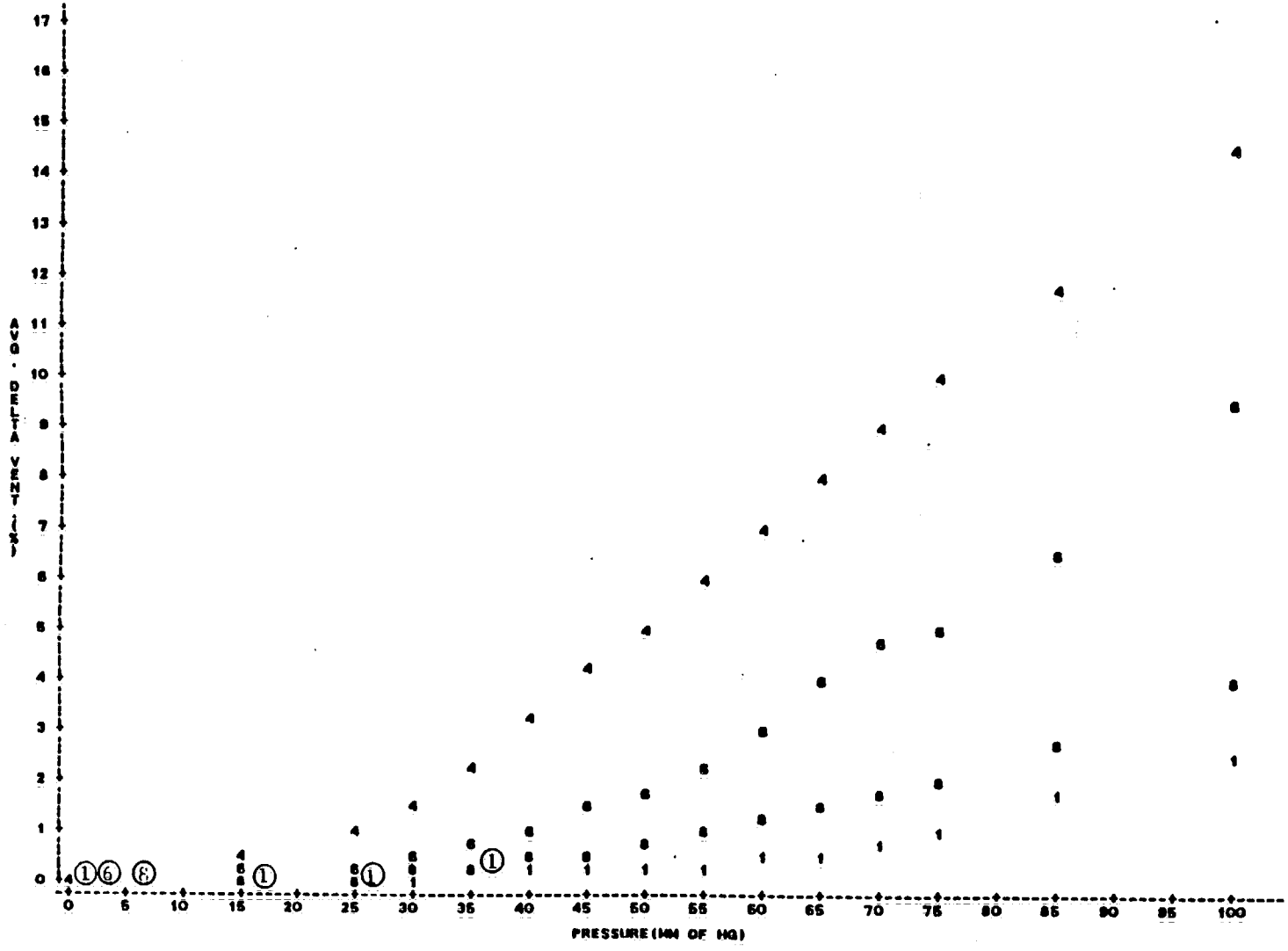
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 11

PLOT OF AVERAGE EFFECTS ON CIGARETTE VENTILATION AT DIFFERENT PRESSURES AND INSERTION LENGTHS

NOTE : 1 = 10MM(12), 4 = 4MM(12), 6 = 6MM(12), 8 = 8MM(12)
WHERE ( ) IS THE HOLDER SIZE IN MM
MODULUS=LOW



○ - Indicates Hidden Observation

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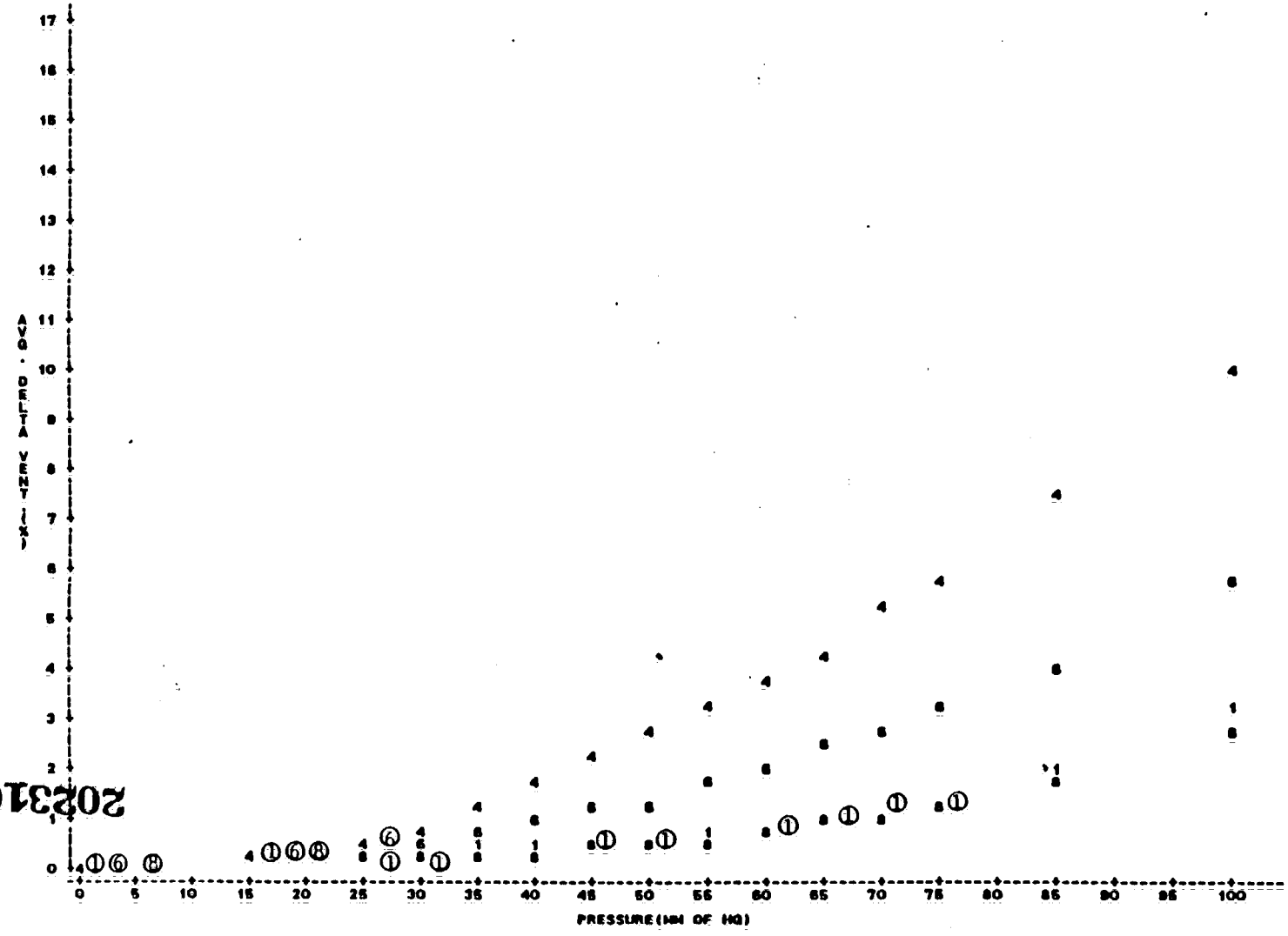
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 12

PLOT OF AVERAGE EFFECTS ON CIGARETTE VENTILATION AT DIFFERENT PRESSURES AND INSERTION LENGTHS

NOTE : 1 = 10MM(12), 4 = 4MM(12), 6 = 6MM(12), 8 = 8MM(12)
WHERE ( ) IS THE HOLDER SIZE IN MM
MODULUS=MED



○ - Indicates Hidden Observation

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 13

Regression Analyses for Average Change in
Cigarette Ventilation (%) versus Pressure (mm of Hg)

MODEL: $Y = A + BX^2$ where Y is the average change in cigarette ventilation and X is pressure.

Modulus	Insertion Length (mm)	Coefficients A	Coefficients $B(X10^{-3})$	Correlation Coefficient r^2
Low	4	0.737797	1.535284	0.97
	6	-0.376379	0.9767059	0.99
	8	-0.162277	0.4009607	0.99
	10	-0.252144	0.2407161	0.92
Medium	4	0.038224	1.017139	0.99
	6	0.012829	0.5707385	0.99
	8	-0.054039	0.2507447	0.97
	10	-0.048470	0.2827123	0.96

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 14

Initial Smoke Deliveries for BARCLAY KS
Nonmenthol Samples

Measurements	$\bar{x}$	s	n
Tar (mg/cig.)	0.3	0.1	7
Nicotine (mg/cig.)	0.07	0.03	9
CO (mg/cig.)	0.5	0.1	19
Puffs (/cig.)	8.5	0.3	19

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 15

SUMMARY STATISTICS FOR SMOKE DELIVERIES BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=TAR(MG/CIG)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		0.93	0.38	54.00
MEDIUM		0.83	0.37	54.00
	INSERTION LENGTH			
MEAN	4MM	0.98	0.47	36.00
	6MM	0.81	0.36	36.00
	8MM	0.74	0.22	36.00
	PRESSURE(MM OF HG)			
MEAN	35MM	0.69	0.17	36.00
	60MM	0.72	0.28	36.00
	85MM	1.22	0.38	36.00
MEAN		0.88	0.38	108.00

VARIABLE=NICOTINE(MG/CIG)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		0.12	0.05	54.00
MEDIUM		0.10	0.04	54.00
	INSERTION LENGTH			
MEAN	4MM	0.12	0.05	36.00
	6MM	0.11	0.05	36.00
	8MM	0.09	0.03	36.00
	PRESSURE(MM OF HG)			
MEAN	35MM	0.08	0.02	36.00
	60MM	0.10	0.03	36.00
	85MM	0.15	0.04	36.00
MEAN		0.11	0.04	108.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 16

SUMMARY STATISTICS FOR SMOKE DELIVERIES BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=CO(MG/CIG)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		0.51	0.36	108.00
MEDIUM		0.48	0.28	107.00
	INSERTION LENGTH			
MEAN	4MM	0.56	0.40	72.00
	6MM	0.50	0.32	72.00
	8MM	0.43	0.22	71.00
	PRESSURE(MM OF HG)			
MEAN	35MM	0.32	0.14	72.00
	50MM	0.45	0.24	71.00
	85MM	0.71	0.40	72.00
MEAN		0.49	0.32	215.00

VARIABLE=FILTER_NICOTINE(MG/CIG)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		0.34	0.07	54.00
MEDIUM		0.34	0.06	54.00
	INSERTION LENGTH			
MEAN	4MM	0.36	0.08	36.00
	6MM	0.35	0.06	36.00
	8MM	0.32	0.05	36.00
	PRESSURE(MM OF HG)			
MEAN	35MM	0.29	0.04	36.00
	60MM	0.34	0.06	36.00
	85MM	0.39	0.06	36.00
MEAN		0.34	0.06	108.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 17

SUMMARY STATISTICS FOR SMOKE DELIVERIES BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=FILTER_EFFICIENCY(%)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		76.20	4.05	54.00
MEDIUM		77.41	4.42	54.00
	INSERTION LENGTH			
MEAN	4MM	74.88	3.60	36.00
	6MM	76.36	5.25	36.00
	8MM	77.68	3.69	36.00
	PRESSURE(MM OF HG)			
MEAN	35MM	78.47	3.39	36.00
	60MM	77.68	3.90	36.00
	85MM	72.89	3.61	36.00
MEAN		76.31	4.36	108.00

VARIABLE=H2O(MG/CIG)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		0.17	0.06	54.00
MEDIUM		0.18	0.05	54.00
	INSERTION LENGTH			
MEAN	4MM	0.18	0.05	36.00
	6MM	0.17	0.07	36.00
	8MM	0.16	0.05	36.00
	PRESSURE(MM OF HG)			
MEAN	35MM	0.15	0.05	36.00
	60MM	0.19	0.06	36.00
	85MM	0.18	0.06	36.00
MEAN		0.17	0.06	108.00

VARIABLE=PUFF(/CIG)

		RESULT		
		MEAN	STD	N
MODULUS				
LOW		8.29	0.34	108.00
MEDIUM		8.24	0.39	108.00
	INSERTION LENGTH			
MEAN	4MM	8.19	0.37	72.00
	6MM	8.30	0.30	72.00
	8MM	8.31	0.42	72.00
	PRESSURE(MM OF HG)			
MEAN	35MM	8.24	0.34	72.00
	60MM	8.28	0.36	72.00
	85MM	8.28	0.41	72.00
MEAN		8.27	0.37	216.00

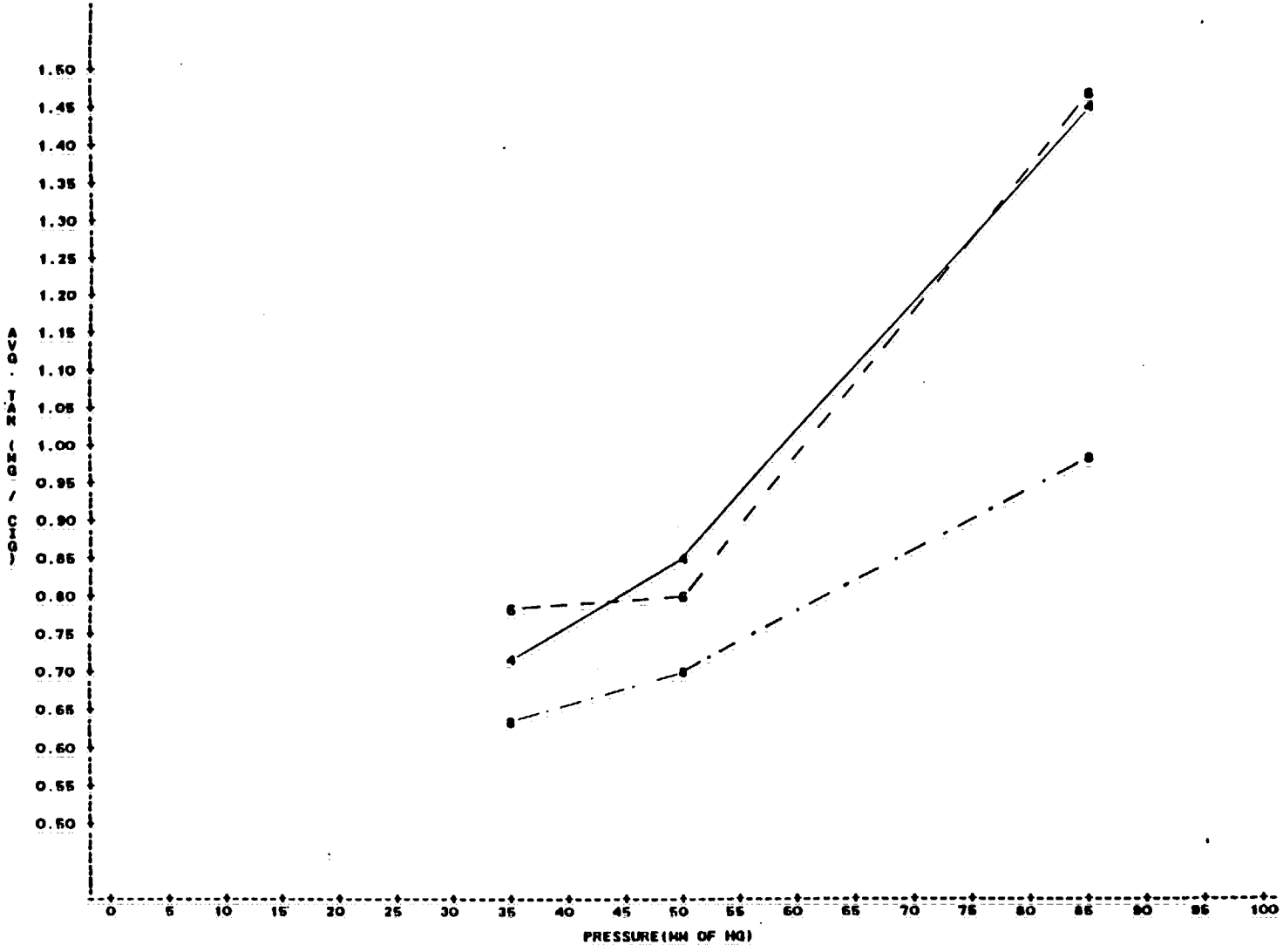
2023100121

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure 18

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW

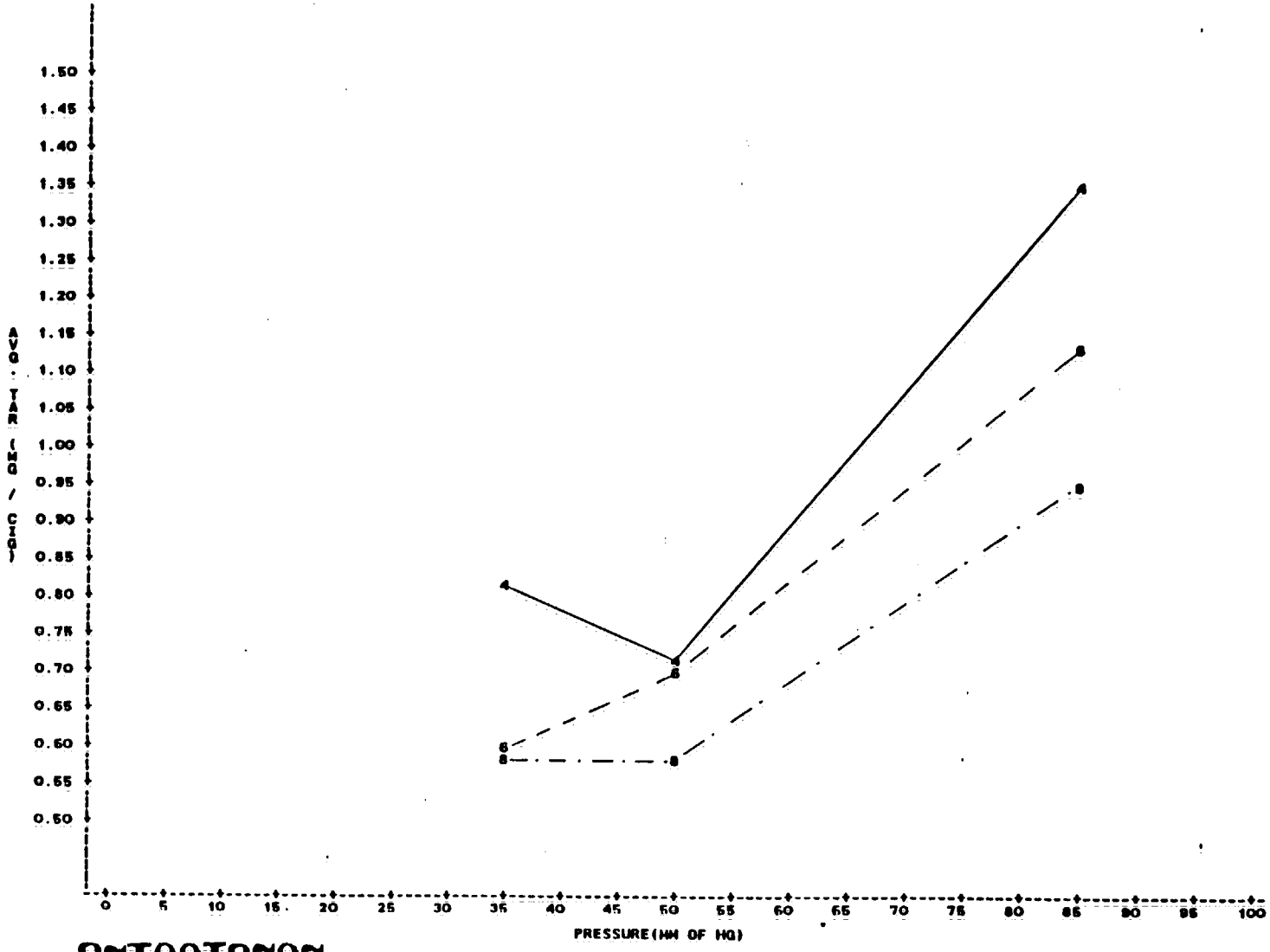


2023100122

Figure 19

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM

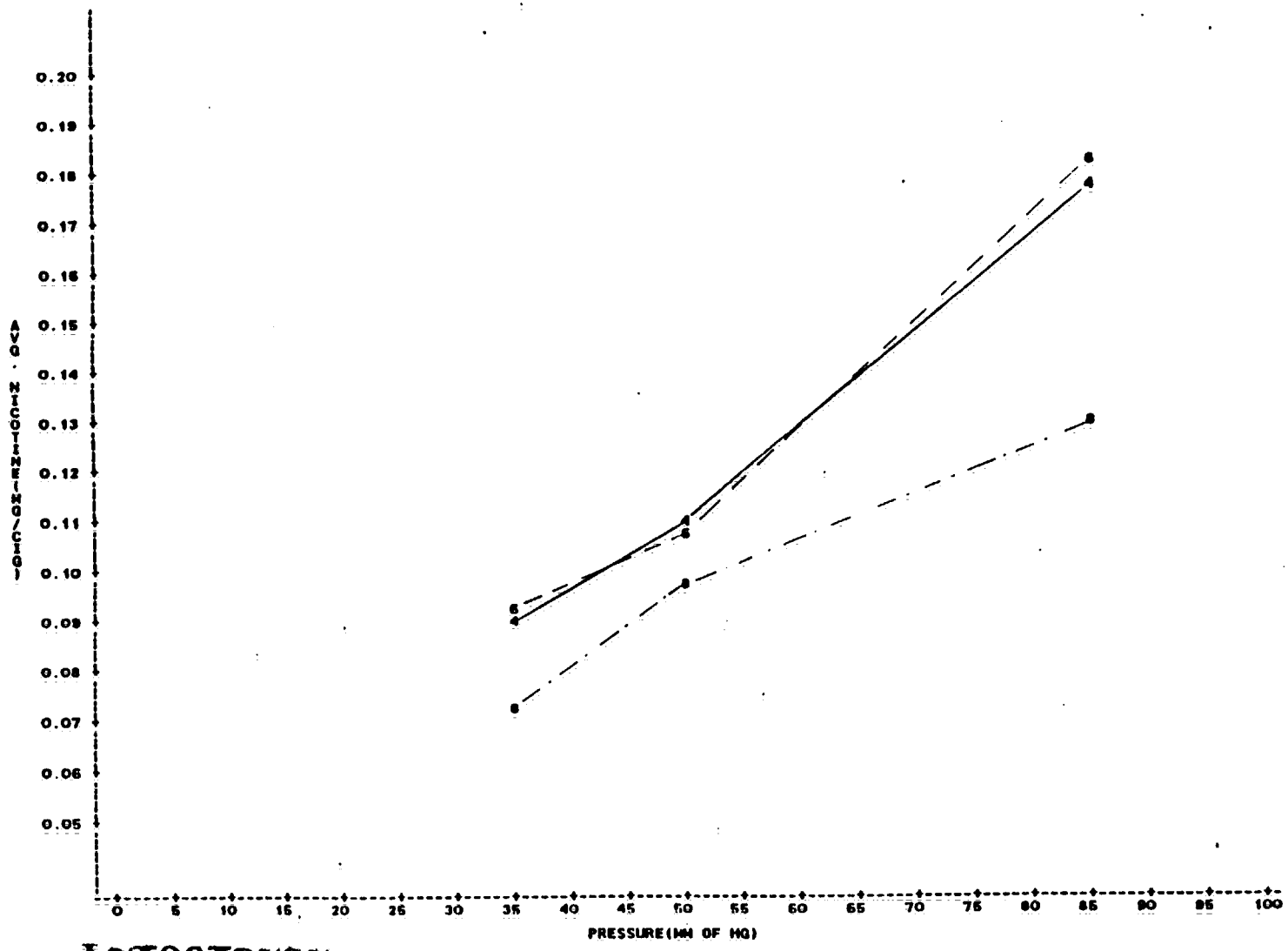


2023100123

Figure 20

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW

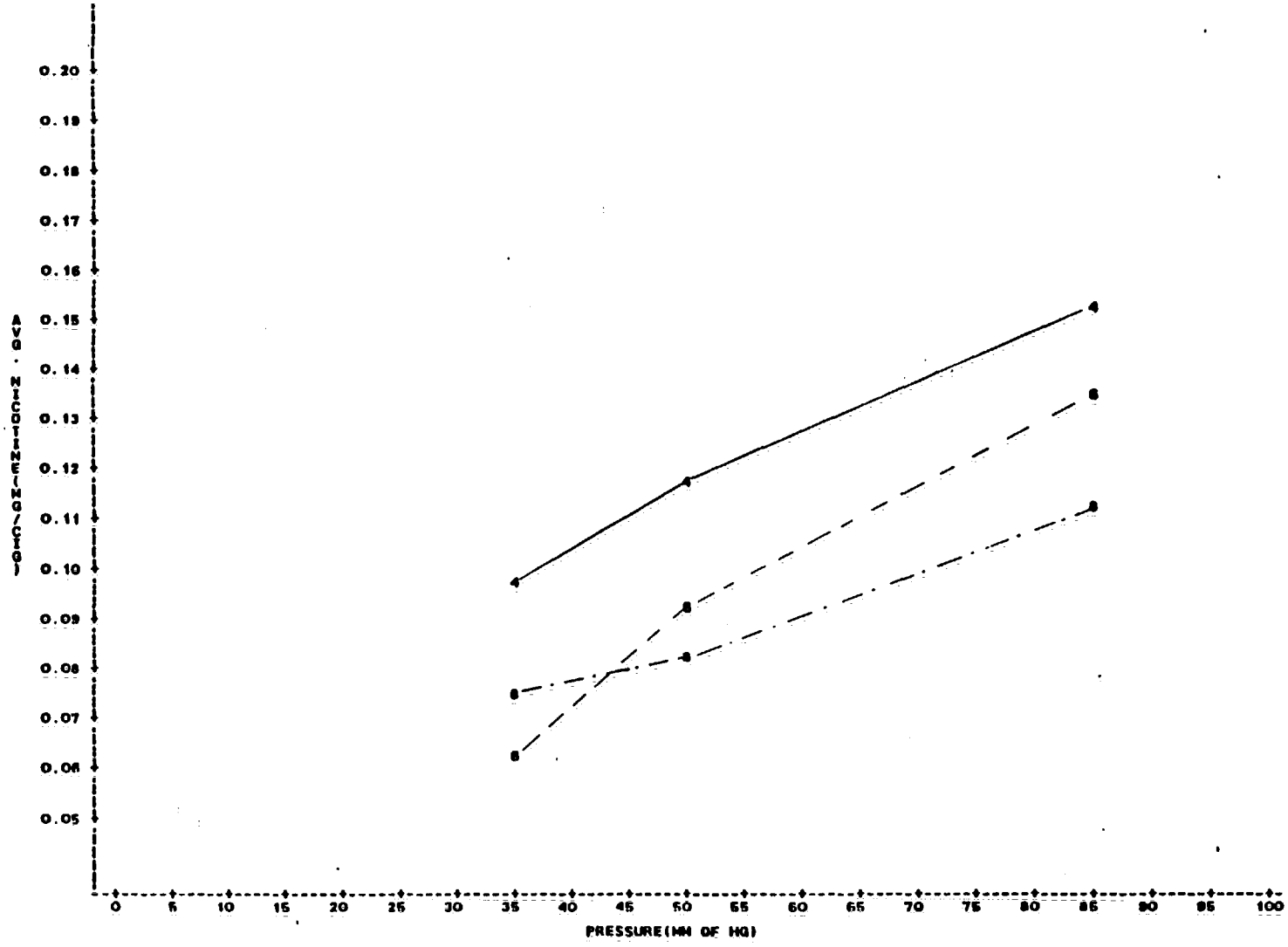


2023100124

Figure 21

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM

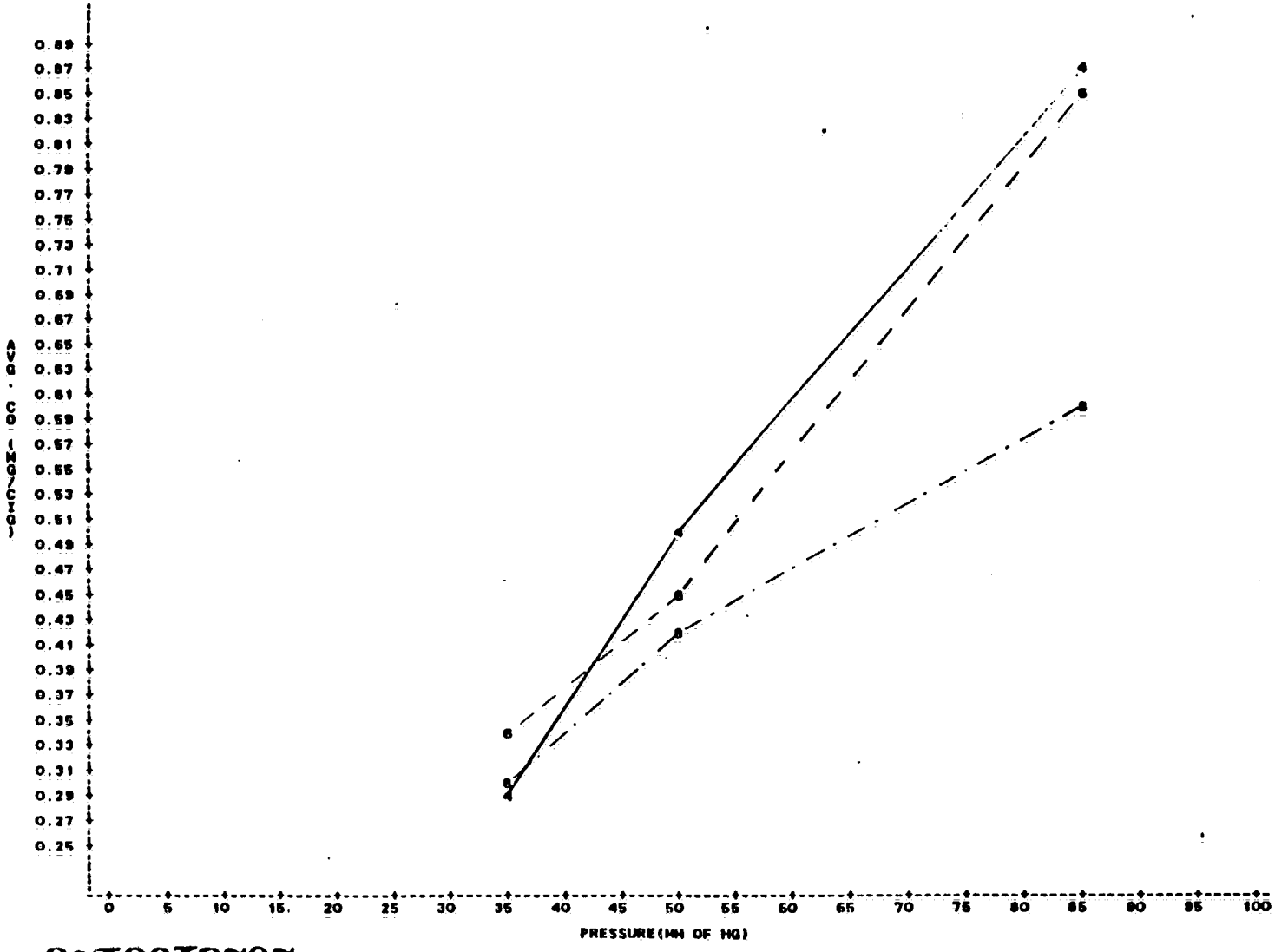


2023100125

Figure 22

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW

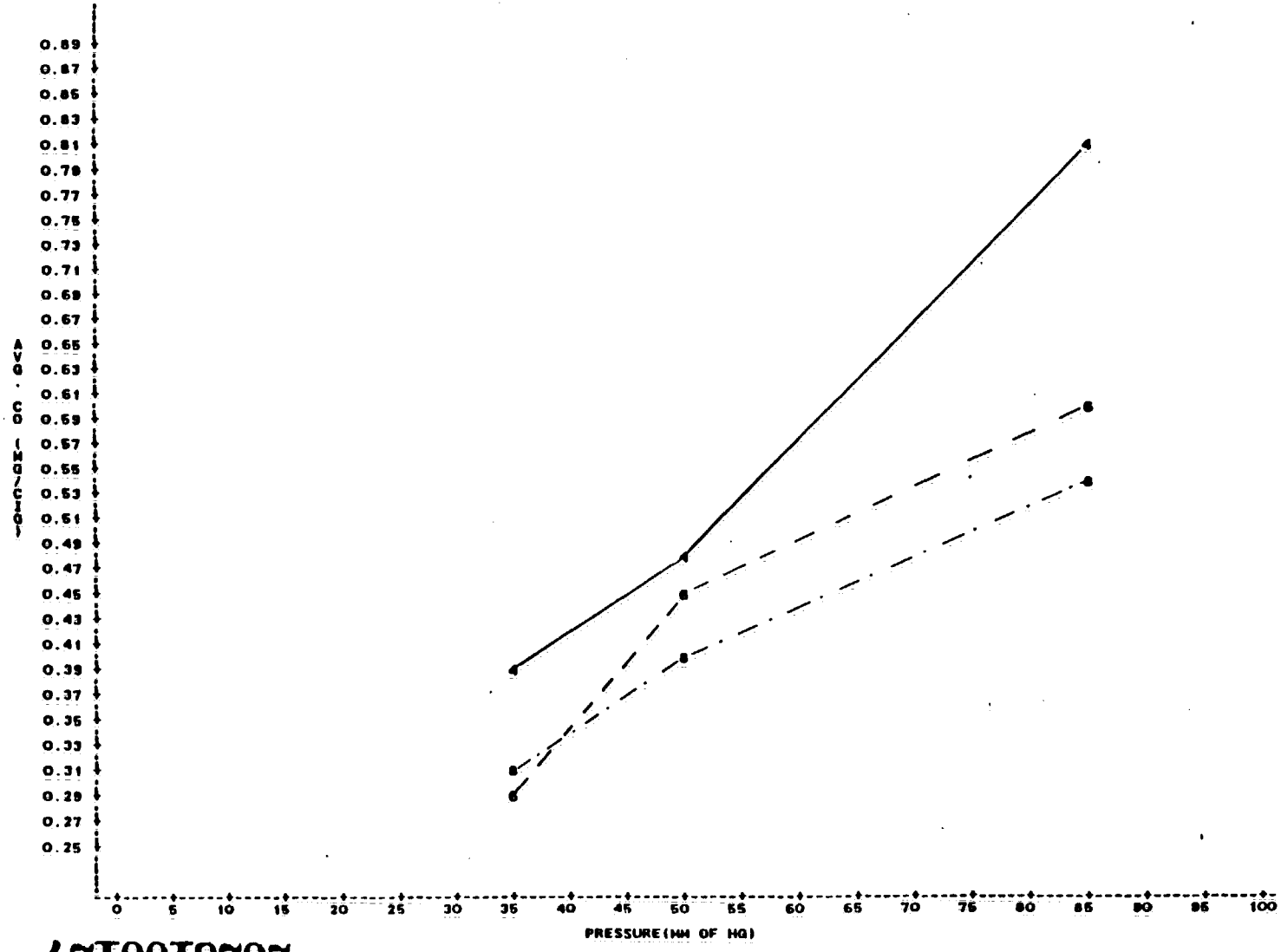


2023100126

Figure 23

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM

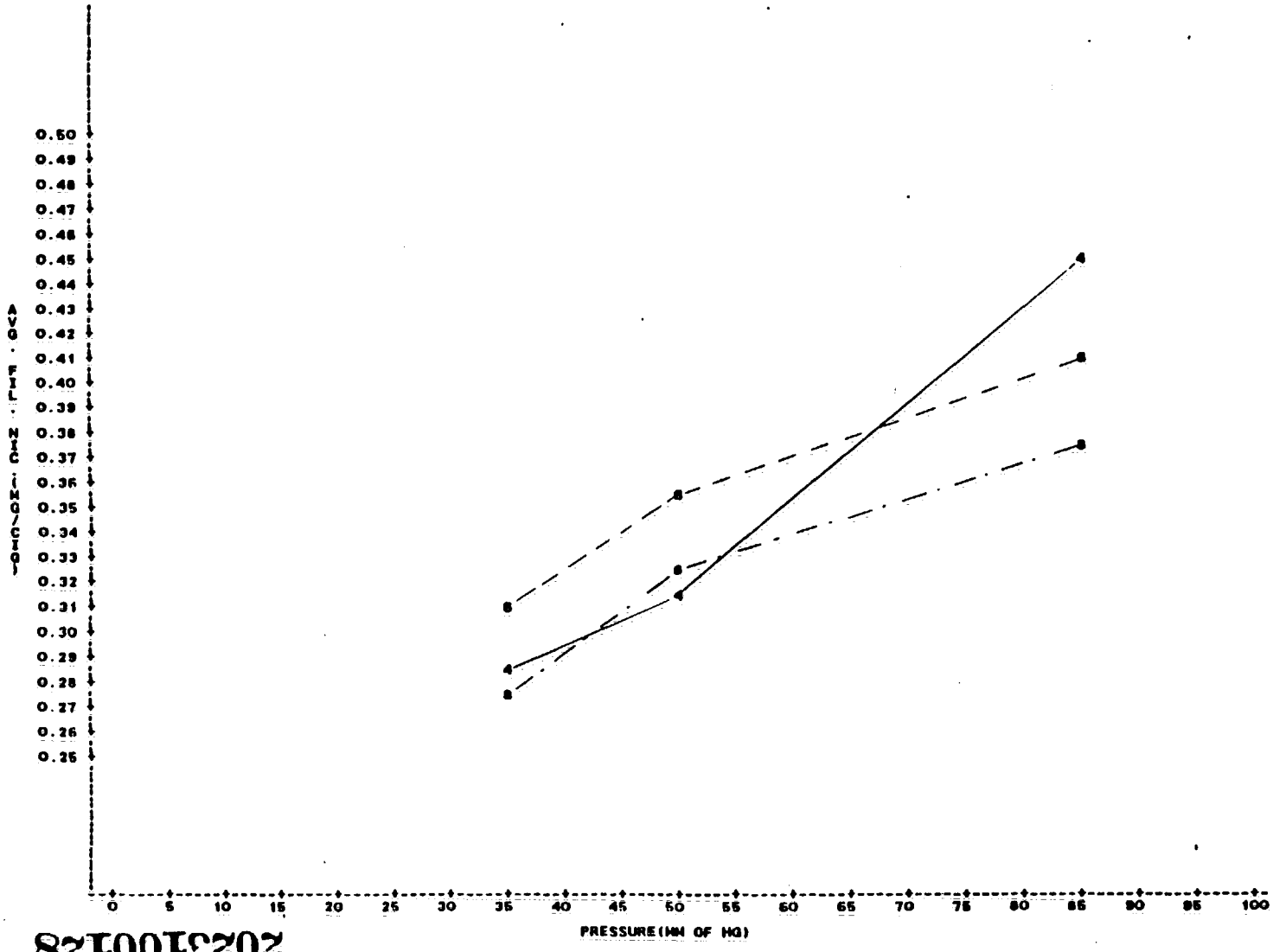


2023100127

Figure 24

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW

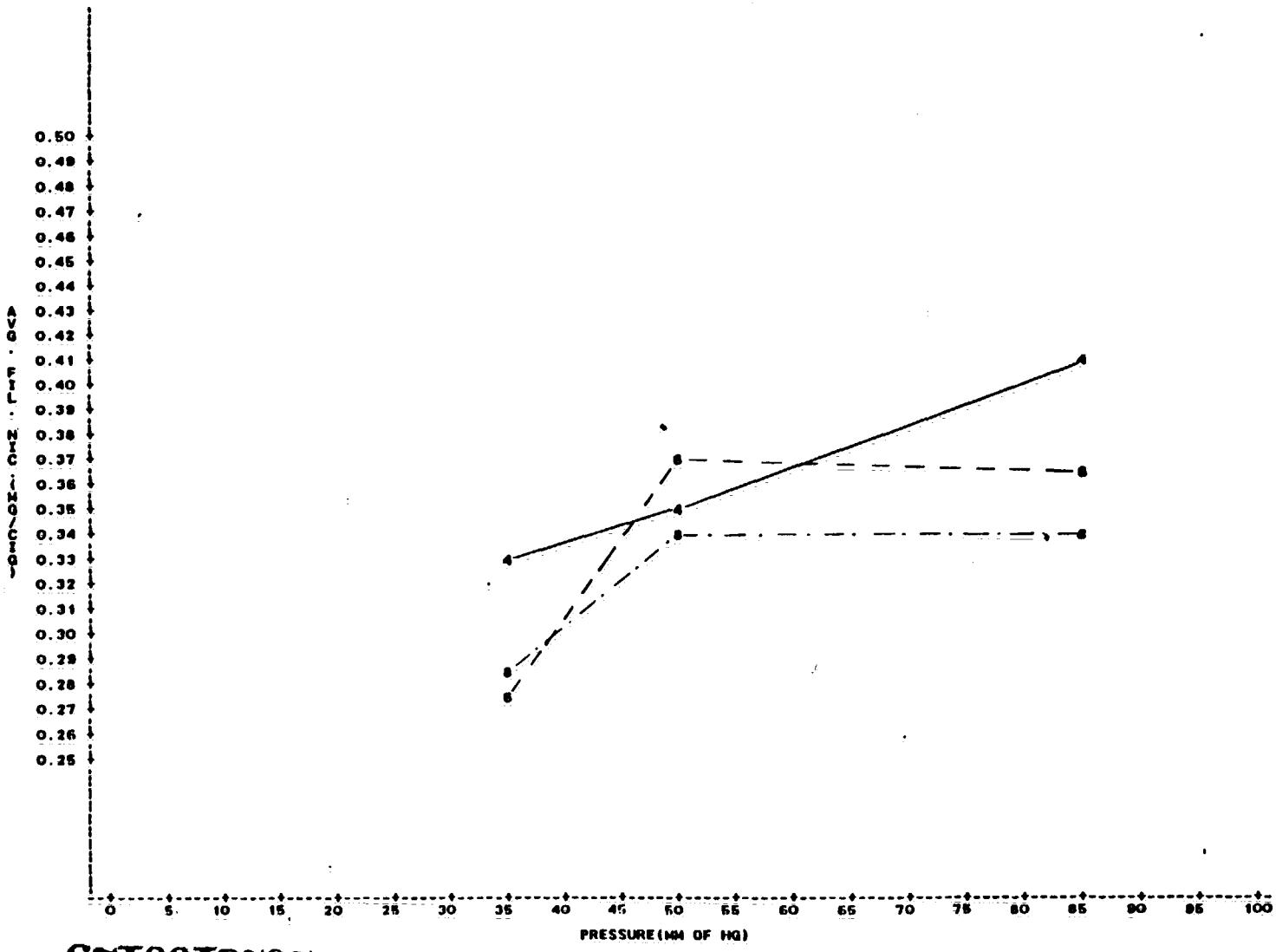


2023100128

Figure 25

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM

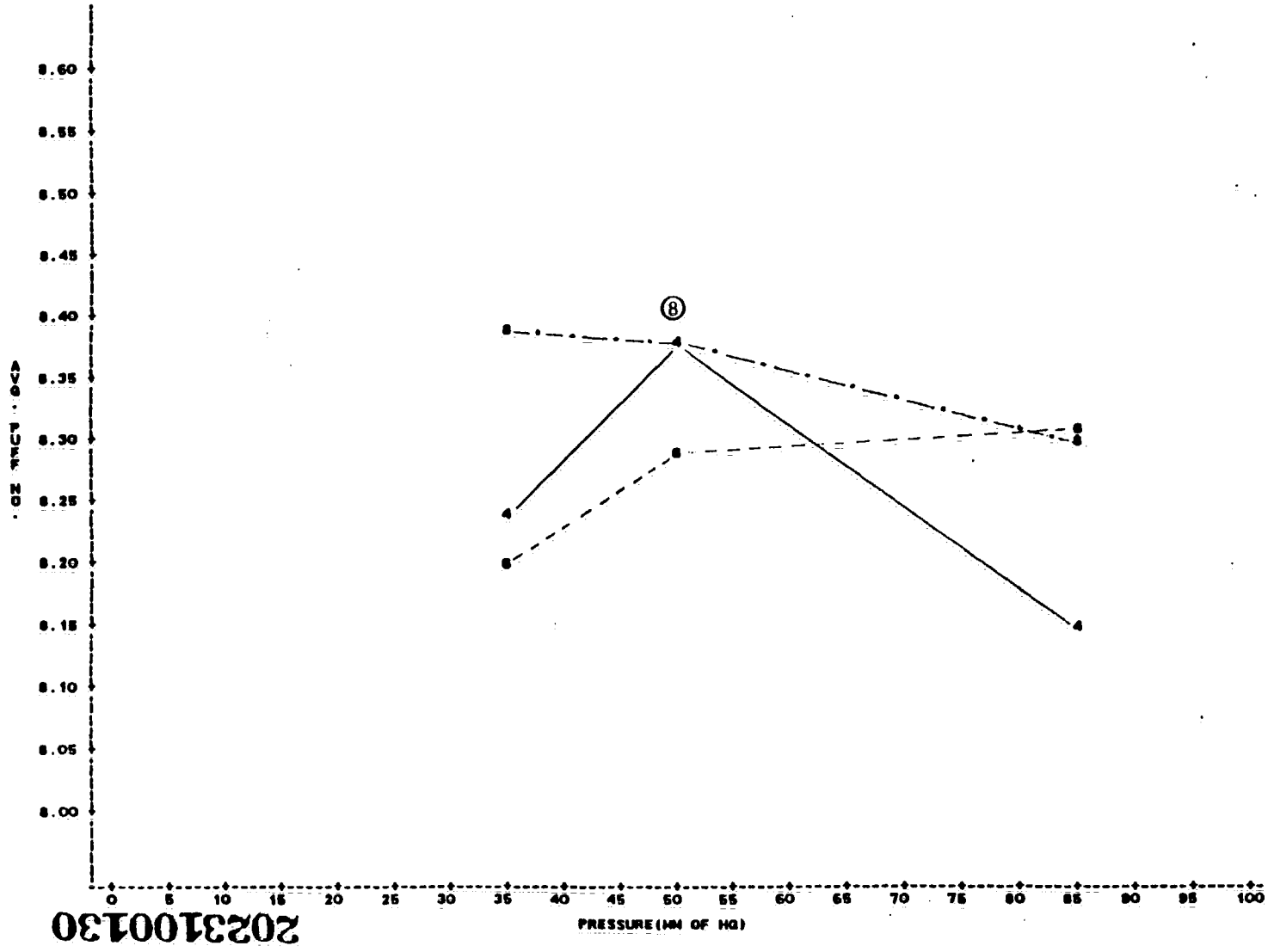


2023100129

Figure 26

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW



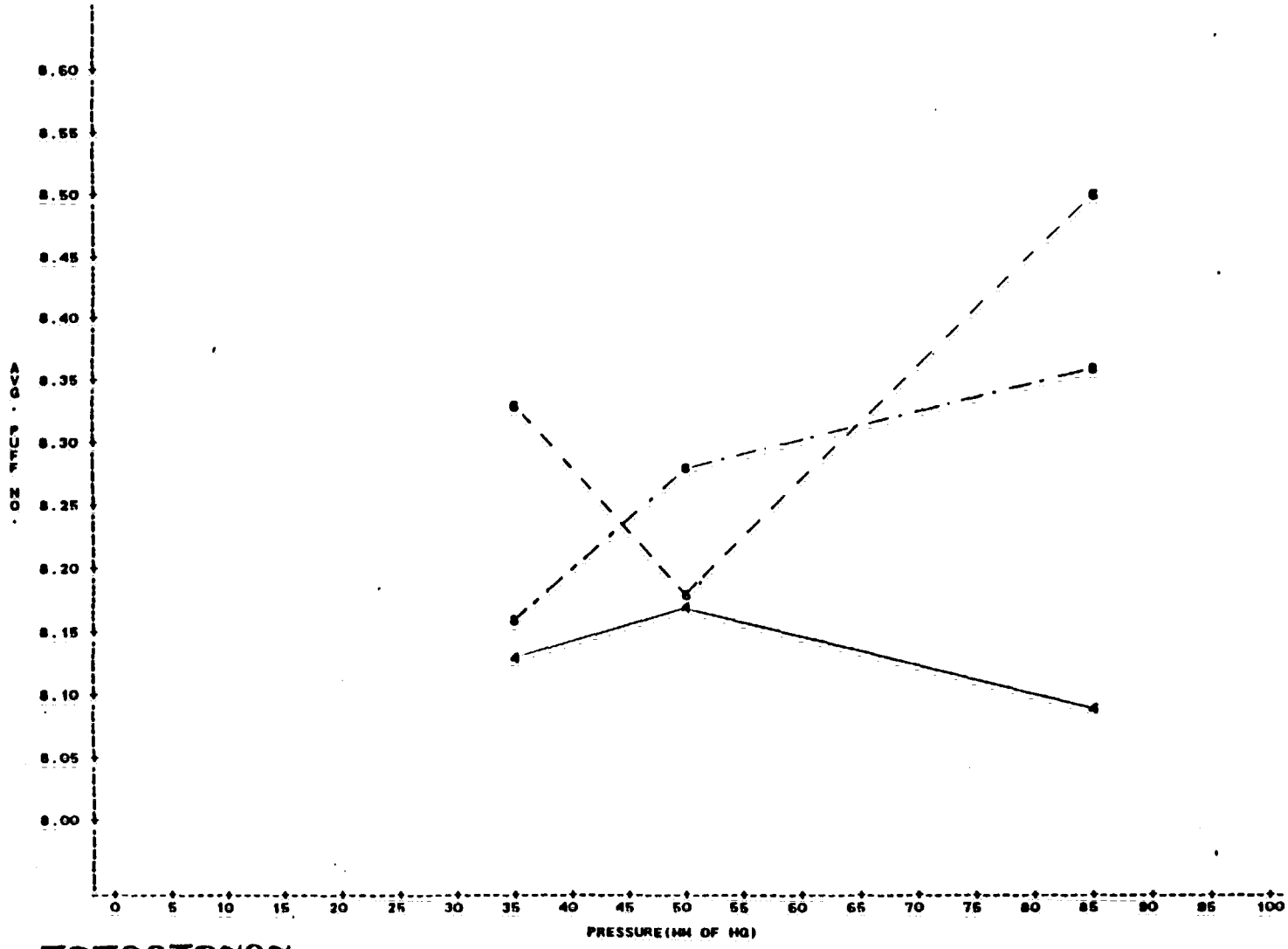
2023100130

○ - Indicates Hidden Observation

Figure 27

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM

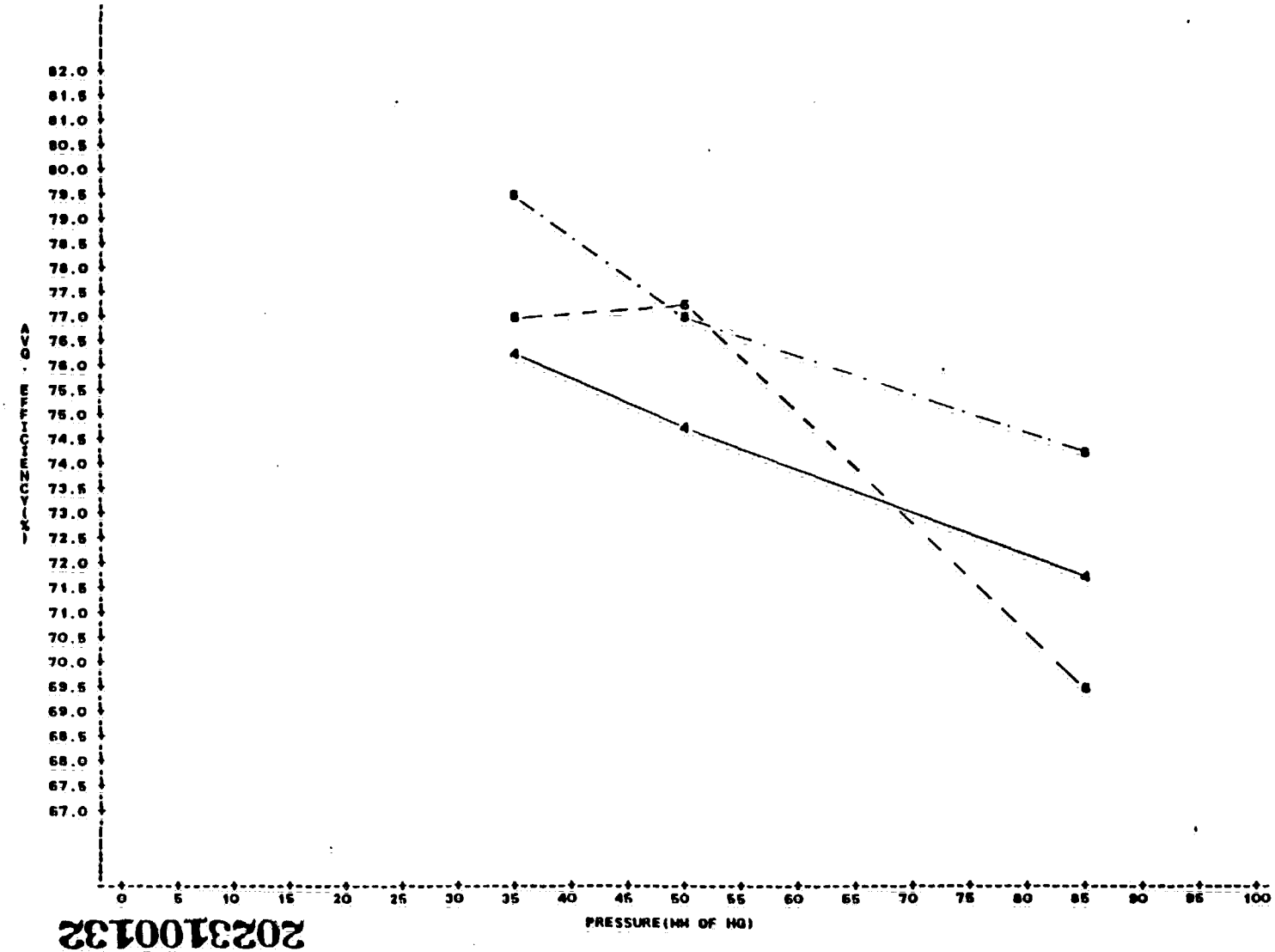


2023100131

Figure 28

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW

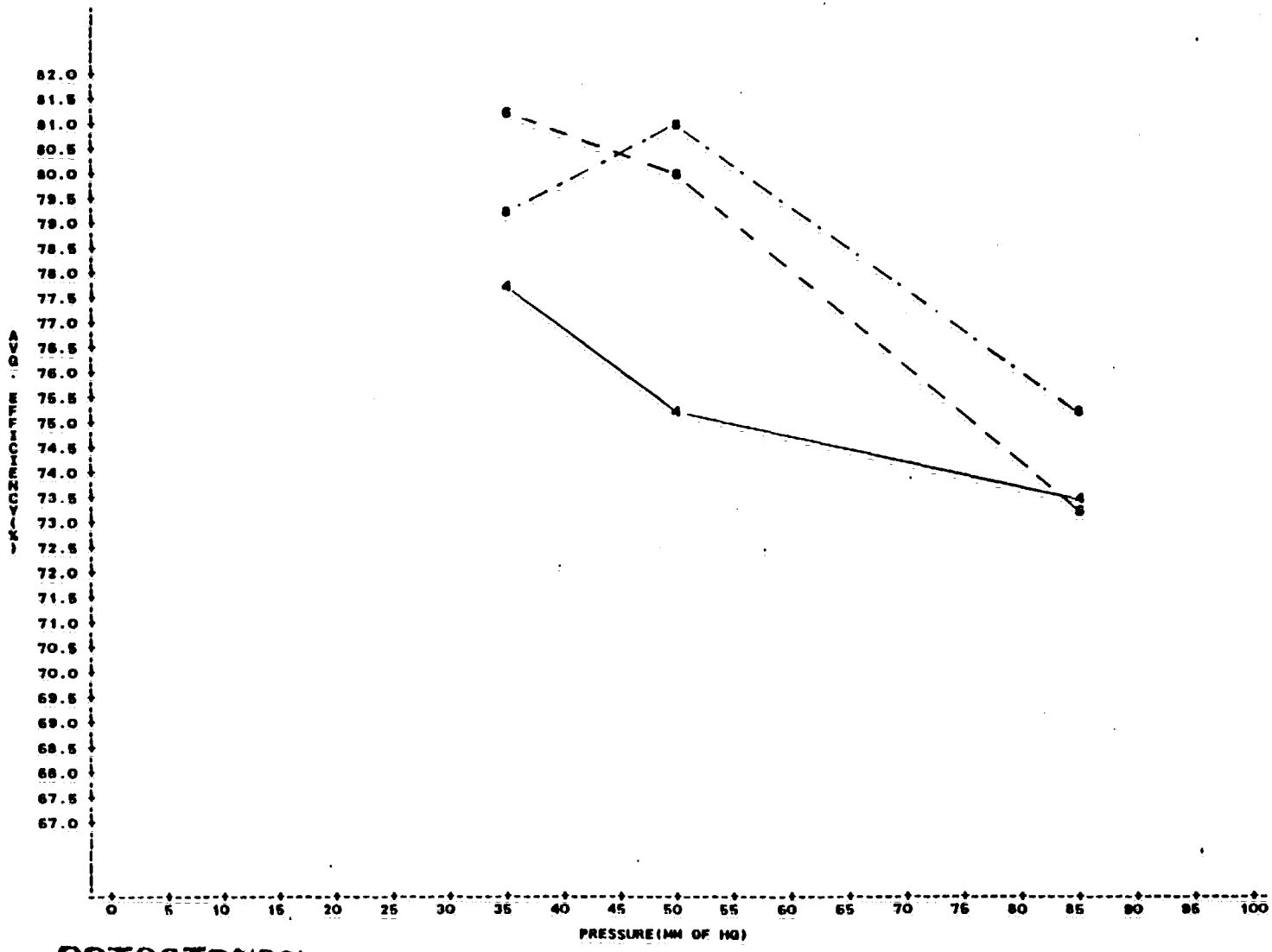


2023100132

Figure 29

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM

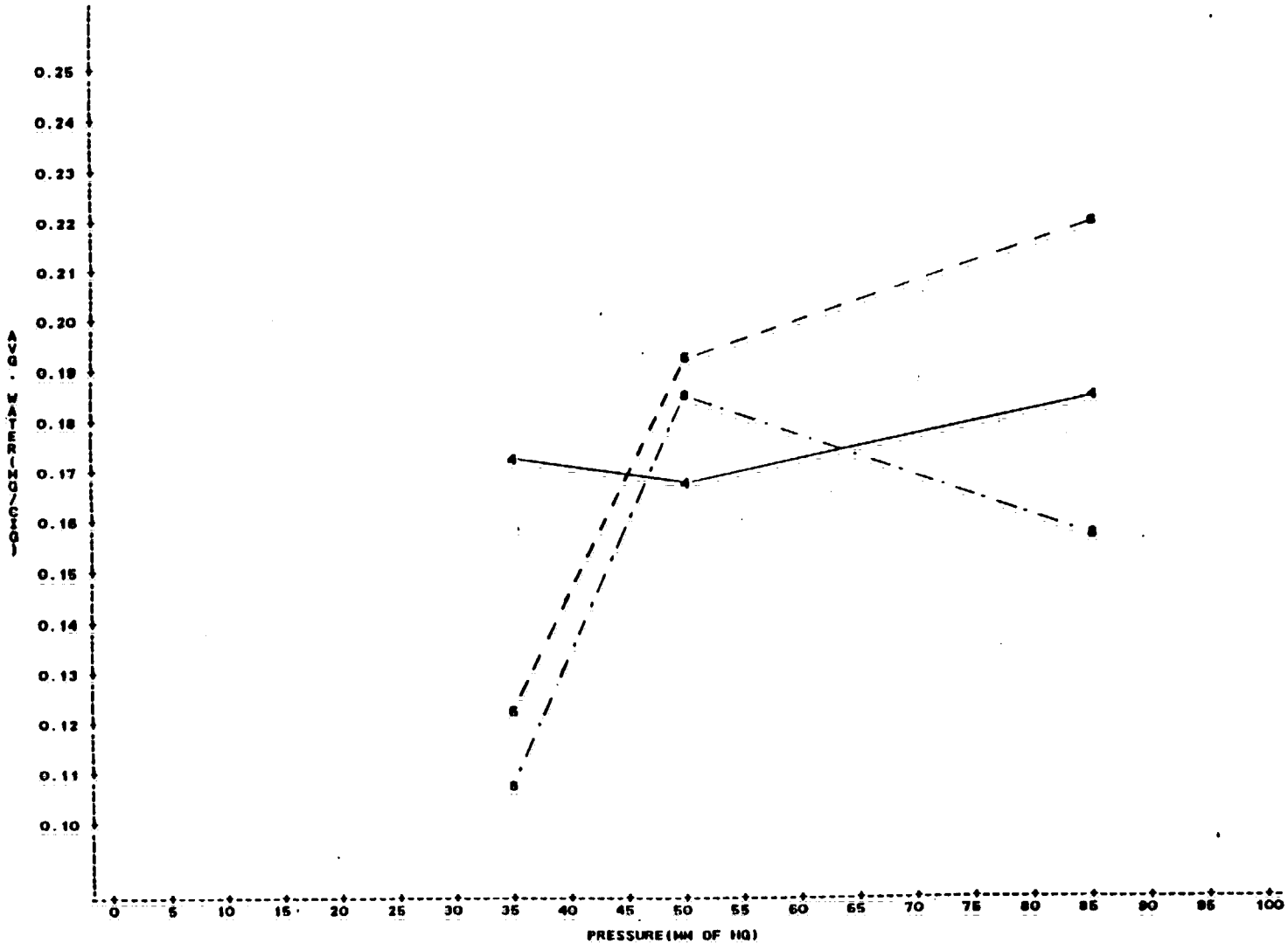


2023100133

Figure 30

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=LOW

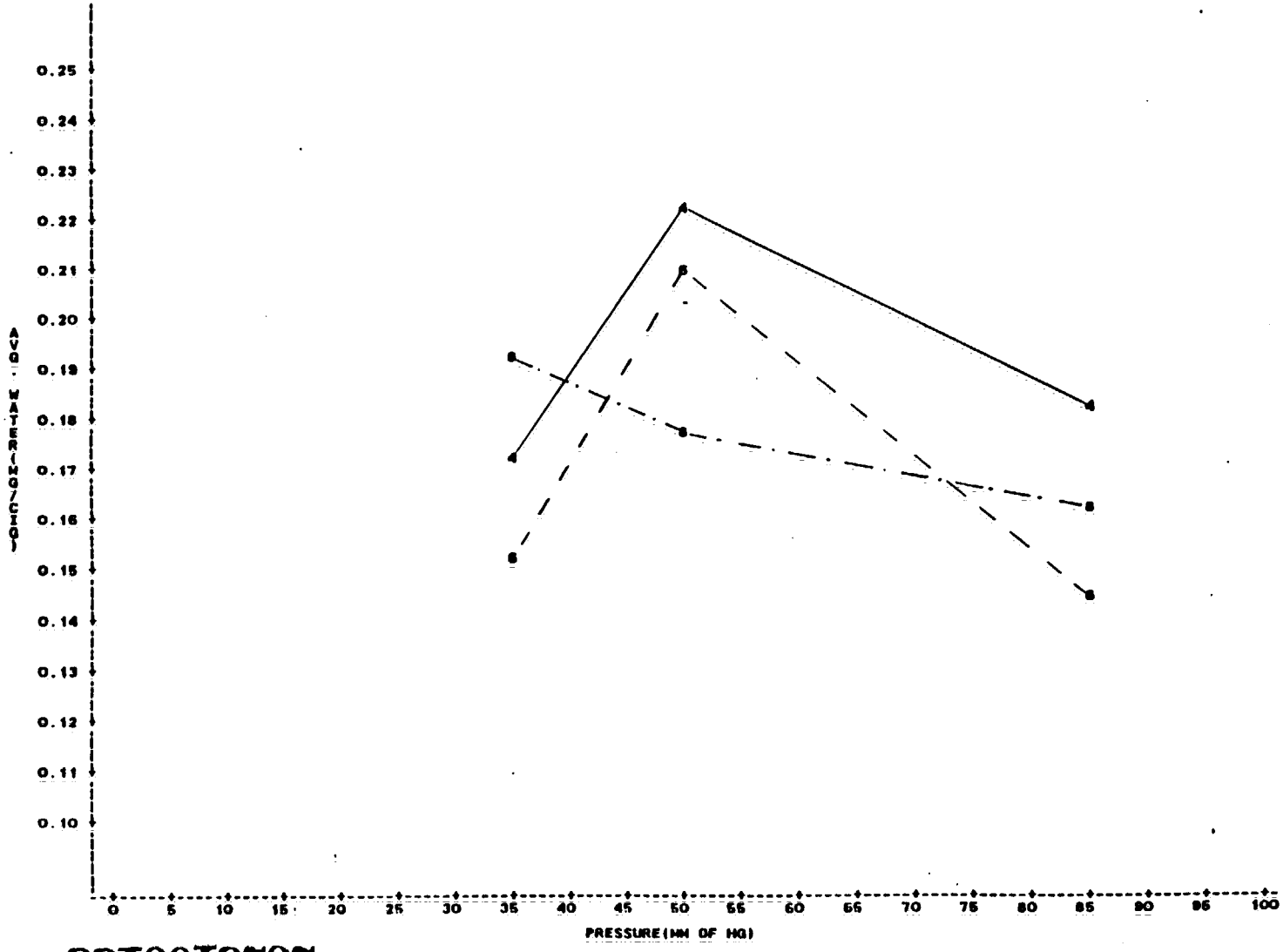


2023100134

Figure 31

PLOT OF PRESSURE EFFECTS ON SMOKE DELIVERIES AT DIFFERENT INSERTION DEPTS BY TYPE OF MODULUS FOR 12MM HOLDER

NOTE: 4 = 4MM, 6 = 6MM AND 8 = 8MM
MODULUS=MEDIUM



2023100135

Figure 32

Experimental Determination of Pressure that is Necessary to Obtain Approximately 60% Cigarette Ventilation and Its Effect on Smoke Deliveries

Smoke Deliveries at 175 mm (Hg) of Pressure

Modulus	Insertion Length (mm)		Tar (mg/cig)	Nicotine (mg/cig)	CO (mg/cig)	Filter Nicotine (mg/CO)	Puff (/cig.)	Filter Efficiency (%)	H_2O (mg/cig)		Pressure (mm of Hg)	Cigarette Ventilation (%)		
Medium	6 mm		3.2	0.38	2.7	0.63	8.4	62.4	0.48		150	51.3	57.6	48.2
			4.0	0.48	3.8	0.73	8.0	60.3	0.63		163	61.1	59.5	
			5.0	0.58	4.7	0.82	7.9	58.6	0.74		175	62.0	61.0	61.9
			3.8	0.47	3.5	0.74	7.9	61.2	0.70		213	61.6		
			3.5	0.43	2.9	0.68	7.6	61.3	0.46		225	65.7		
			5.4	0.60	5.1	0.86	7.5	58.9	0.66	$\bar{x}$ =	174	58.9		
			3.9	0.48	3.6	0.73	8.3	60.8	0.64	s =	26.0	5.33		
			3.9	0.46	3.5	0.67	7.9	59.3	0.62	n =	10	10		
		$\bar{x}$ =	4.1	0.49	3.7	0.73	7.9	60.3	0.62					
		s =	0.74	0.07	0.82	0.08	0.31	1.31	0.10					
		n =	8	8	8	8	8	8	8					
Medium	8 mm		3.1	0.36	2.2	0.57	8.3	61.3	0.48		175	65.2	68.3	71.2
			4.8	0.56	4.3	0.82	7.9	59.4	0.57		175	47.5	73.9	65.8
			2.2	0.31	1.9	0.62	8.3	66.7	0.26		175	56.1		
			3.2	0.36	2.3	0.60	8.4	62.5	0.28					
			2.7	0.89	2.5	0.65	8.0	42.2	0.44					
			2.2	0.43	2.1	0.55	8.3	56.1	0.40					
			3.4	0.42	2.8	0.68	8.1	61.8	0.38	$\bar{x}$ =	175	64.0		
			1.9	0.25	1.5	0.55	8.3	68.8	0.28	s =	0	9.20		
		$\bar{x}$ =	2.9	0.45	2.5	0.63	8.2	59.9	0.39	n =	7	7		
		s =	0.93	0.20	0.84	0.09	0.18	8.16	0.11					
		n =	8	8	8	8	8	8	8					

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

APPENDIX A

CIGARETTE VENTILATION DATA

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure A1

LISTING OF VENTILATION FOR INDIVIDUAL CIGARETTES BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES FOR LOW MODULUS

HOLDER 12MM

		CIGARETTE 1 VENTILATION %	2 VENTILATION %	3 VENTILATION %	4 VENTILATION %	5 VENTILATION %	6 VENTILATION %	7 VENTILATION %	8 VENTILATION %	9 VENTILATION %	10 VENTILATION %	11 VENTILATION %	12 VENTILATION %	AVG.	STD.	N
INSERTION LENGTH	PRESSURE(MM OF HG)															
4MM	0MM	82.8	88	86.5	89.9	79.8	83.6	83.5	87.5	84.4	85.8	86.9	87	85.47	2.76	12.00
	15MM	82.5	87.7	86.4	89.8	79.4	82.8	82.9	87.2	83.9	83.8	86.7	86.8	85.00	2.90	12.00
	25MM	82.1	87.6	86.1	89.5	77.6	82.4	82.3	86.4	83.5	83.3	85.9	86.5	84.43	3.19	12.00
	30MM	81.8	87.5	85.8	89.1	76.1	82.2	82.3	86	83	82.2	84.9	86.2	83.93	3.43	12.00
	35MM	81.2	87.6	85.4	88.5	74.4	81.4	82.2	85	82.5	81	83.5	84.9	83.13	3.69	12.00
	40MM	80.9	87.9	85	88.1	72.5	80.5	81.9	83.8	81.7	79.5	81.5	83.9	82.27	4.11	12.00
	45MM	80.2	88.1	84.1	87.7	71	79.4	81.8	83.1	81	78.5	78.3	83.9	81.26	4.75	12.00
	50MM	80	88.1	83.6	87.4	69.4	78.1	81.7	82.2	80.4	74	76.7	83.1	80.39	5.32	12.00
	55MM	79.5	87.9	83.1	87	67	77.1	81.6	81.6	79.8	70.6	75.9	82.5	79.47	6.12	12.00
	60MM	79	87.7	82.7	86.2	65	75.8	81.3	80.7	79	67.5	74.6	81.9	78.45	6.82	12.00
	65MM	78.4	87.7	82.1	85.4	63.1	74.9	80.9	80.4	78.5	64.2	73.3	81	77.49	7.57	12.00
	70MM	78	87.5	81.4	84.7	60.4	73.8	80.8	79.7	77.9	60.3	72	80.3	76.40	8.57	12.00
	75MM	77.5	87.5	80.6	84.2	58.6	72.8	80.6	79.2	77	57.8	71.1	79.7	75.53	9.22	12.00
	85MM	76.4	87.2	79.1	82.9	54.3	69.3	79.9	78.4	75.9	53.9	68.5	77.5	73.61	10.44	12.00
	100MM	75.1	86.6	76.3	80.2	49.5	66	78.8	76	74.3	48.1	66.2	74.6	70.97	11.74	12.00
6MM	0MM	87.9	82.1	86.6	89.6	89.5	88.5	89.9	84.4	80.1	81.7	83.8	80	85.34	3.78	12.00
	15MM	87.7	81.9	86.5	89.4	89.3	88.3	89.9	84.5	80.1	81.4	83.6	80	85.22	3.76	12.00
	25MM	87.7	82.1	86.3	89.3	89.2	88	89.9	84.5	79.5	81.1	83.1	79.9	85.05	3.84	12.00
	30MM	87.5	82	86	89.4	89.1	87.9	89.7	84.5	79.2	80.7	83.1	79.9	84.92	3.87	12.00
	35MM	87.4	81.9	85.6	89.2	88.9	87.5	89.8	84.5	79	80.3	81.9	79.8	84.65	3.95	12.00
	40MM	87.3	81.5	84.9	89.1	88.6	86.6	89.7	84.4	78.7	79.3	81.7	79.8	84.30	4.01	12.00
	45MM	87.2	81.2	84	88.8	87.9	86.1	89.6	84.2	78.4	78.8	81.5	79.7	83.96	3.99	12.00
	50MM	87.1	80.6	83.3	88.1	87.5	84.9	89.5	84	78.4	78.1	81	79.7	83.62	3.96	12.00
	55MM	86.9	80.4	82.1	87.4	87	83.7	89.2	83.6	77.8	77.7	80.9	79.5	83.02	3.92	12.00
	60MM	86.5	79.1	79.8	87	86.3	82.1	88.7	83	77.3	77.1	80.8	79.4	82.26	4.00	12.00
	65MM	85.7	77.9	77.4	86.5	85.5	81.2	87.9	82.4	76.7	76.4	80.6	79.3	81.47	4.11	12.00
	70MM	84.7	77.2	76.2	86.4	84.9	79.8	87.4		76.1	75.5	80.4	79.2	80.71	4.41	11.00
	75MM	84.2	76.5	75.2	85.7	84.6	78.5	86.9	81.8	75.3	75.1	80.2	79.2	80.27	4.32	12.00
	85MM	83.1	75	72.2	84.6	83.3	75.4	86	81	74.2	73.9	79.6	77.7	78.83	4.73	12.00
	100MM	82.2	72.8	67.4	82.7	81.6	70.5	73	79.8	73	71	78.3	77.1	75.77	5.14	12.00

(CONTINUED)

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Figure A1 (cont.)

LISTING OF VENTILATION FOR INDIVIDUAL CIGARETTES BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES FOR LOW MODULUS

HOLDER 12MM

		CIGARETTE														
		1	2	3	4	5	6	7	8	9	10	11	12			
		VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	AVG.	STD.	N
INSERTION LENGTH	PRESSURE(MM OF HG)															
8MM	0MM	83.4	86.4	88.2	83.3	86.1	86.3	89.1	85.8	82.6	89	85.6	88.2	86.17	2.22	12.00
	15MM	83.1	86.3	88.2	83.3	86	86.1	89.1	85.6	83.1	89.1	85.5	88	86.12	2.19	12.00
	25MM	82.4	86.2	89.2	83.2	85.9	86.2	89.1	85.6	83	89	84.8	88.1	86.06	2.43	12.00
	30MM	81.7	86.2	88.4	83.2	86	85.9	89	85.3	82.8	88.9	84.5	88	85.82	2.45	12.00
	35MM	81.7	86.1	88.2	83.1	86	85.8	88.9	85.1	82.9	88.7	85.3	88	85.82	2.37	12.00
	40MM	81.5	85.9	88.3	83.3	86.1	85.8	88.9	84.8	82.9	88.8	85.2	87.8	85.78	2.39	12.00
	45MM	81.4	86	88.2	83.2	85.9	85.8	88.6	84.2	82.8	88.8	85.3	87.6	85.63	2.43	12.00
	50MM	80.9	85.9	88.1	83	85.7	85.6	88.2	83.9	82.6	88.7	85.3	87.2	85.42	2.44	12.00
	55MM	81.3	85.9	88.1	82.8	85.7	85.1	87.8	83.2	82.3	88.5	85.2	86.2	85.17	2.36	12.00
	60MM	80.9	85.9	88	82.6	85.6	84.8	87.7	83.1	82	88.3	85	85.8	84.87	2.42	12.00
	65MM	80.4	85.9	88	82.5	85.4	84.4	87.4	82.8	81.7	87.9	84.9	85.7	84.75	2.48	12.00
	70MM	80.1	85.8	87.9	82.4	84.4	84.2	87.3	82.3	81.1	87.7	84.6	85.4	84.43	2.56	12.00
	75MM	79.6	85.6	88	82.2	84.4	83.9	87.1	81.9	80.4	86.6	84.3	85.1	84.09	2.63	12.00
	85MM	78.9	85.4	87.7	81.8	83.8	83	86.8	81.2	78.4	85.8	83.4	84.5	83.38	2.92	12.00
	100MM	77.6	85	87.5	80.9	.	82	85.5	80	75.2	84.2	82.2	83.8	82.17	3.61	11.00
10MM	0MM	87.1	86.6	87.2	87.4	87.9	82.4	82.1	83	87.4	79.2	85.6	82.9	84.90	2.85	12.00
	15MM	86.9	86.6	87.1	87.3	87.9	82.4	82	83.4	87.4	79.1	85.7	82.9	84.89	2.83	12.00
	25MM	86.9	86.6	87.2	87.3	87.8	82.5	82.1	83.1	87.3	79.3	85.7	82.6	84.87	2.80	12.00
	30MM	86.9	86.7	87.3	87.3	87.8	82.5	82.1	83.2	87.3	79.1	85.7	82.7	84.88	2.84	12.00
	35MM	86.9	85.7	87.3	87.1	87.7	82.4	81.9	83	87.3	78.9	85.6	82.5	84.77	2.90	12.00
	40MM	86.9	86.6	87.3	87	87.9	82.4	81.7	83.1	87.3	78.7	85.7	82.5	84.76	2.96	12.00
	45MM	86.9	86.5	87.2	86.9	87.9	82.6	81.8	83.1	87.3	78.5	85.7	82.4	84.73	2.96	12.00
	50MM	86.8	86.7	87.2	86.7	87.8	82.5	81.7	83.2	87.4	78.4	85.7	82.2	84.69	2.98	12.00
	55MM	86.8	86.6	87.3	86.8	87.6	82.4	81.6	83.2	87.4	78.1	85.8	82.1	84.64	3.07	12.00
	60MM	86.7	86.6	87.4	86.3	87.4	82.3	81.3	83.1	87.2	77.8	85.3	81.9	84.44	3.10	12.00
	65MM	86.7	86.6	87.3	86.2	87	82.2	81.3	83.1	87.3	77.5	85.3	81.8	84.36	3.14	12.00
	70MM	86.7	86.4	87.3	86.1	86.4	82.2	81.1	83.1	87.2	76.9	85.5	81.6	84.21	3.23	12.00
	75MM	86.6	86.5	87.4	85.7	85.7	82.2	80.8	83.1	87.2	76.1	85.4	81.5	84.02	3.38	12.00
	85MM	85.5	86.3	87.3	84.1	85.3	81.7	80.1	83.1	87.2	72.1	85.3	80.8	83.23	4.24	12.00
	100MM	84.7	85.3	87.3	82.6	84.3	80.9	78.6	82.9	87.3	69.6	85.2	80.1	82.40	4.85	12.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure A1 (cont.)

LISTING OF VENTILATION FOR INDIVIDUAL CIGARETTES BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES FOR MEDIUM MODULUS

HOLDER 12MM

		CIGARETTE														
		1	2	3	4	5	6	7	8	9	10	11	12			
		VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	VENTILATION %	AVG.	STD.	N
INSERTION LENGTH	PRESSURE(MM OF HG)															
4MM	0MM	85.4	87.6	85.8	89.5	89.6	83.1	.	87.6	85.6	88.1	84.5	88	86.79	2.06	11.00
	15MM	85.2	87.3	85.7	89.4	89.1	82.6	81.3	87.2	85.3	88.1	84.1	87.9	86.09	2.56	12.00
	25MM	85.3	86.8	85.6	89.2	88.8	82.2	81.4	87	84.6	88.1	84.1	87.4	85.87	2.48	12.00
	30MM	85.2	86	85.6	89	88.3	81.8	80.7	86.7	84.1	87.8	84.1	86.7	85.50	2.51	12.00
	35MM	85.4	84.2	85.6	89.1	88.1	81.8	80.6	86.6	83.5	87.5	84	85	85.12	2.51	12.00
	40MM	85.6	83	85.3	89	87.9	81.8	80.3	86.2	82.9	87.3	83.9	83.7	84.74	2.60	12.00
	45MM	85.4	81.5	85	88.8	87.8	81.6	80	86	81.7	87	83.6	82.8	84.27	2.83	12.00
	50MM	85.5	80.2	84.7	88.9	87.6	81.5	79.6	85.7	80.4	86.6	83	81.7	83.78	3.13	12.00
	55MM	85.2	79.3	84.3	88.5	87.5	81.4	78.8	85.3	79.7	86.2	82.6	79.9	83.22	3.39	12.00
	60MM	84.6	78.1	83.7	88	87.2	81	77.1	84.5	79.1	85.3	82	78.6	82.43	3.67	12.00
	65MM	84.2	76.9	83.1	87.8	86.9	80.7	75	84.1	78.5	84.8	82	77.6	81.80	4.09	12.00
	70MM	82.4	75.3	82.2	87.5	86.7	79.8	70.9	84	78.2	84.4	81	76.5	80.75	4.87	12.00
	75MM	82	73.9	81.8	87.3	86.5	79.4	69.4	83.5	77.8	83.7	79.7	75.6	80.05	5.25	12.00
	85MM	80.6	70.1	80.5	86.4	85.7	78.5	66.2	82	76.3	82.8	76.4	73	78.21	6.13	12.00
	100MM	79.2	64.8	78.9	84.3	84.4	77.3	60	80.4	73.5	80.3	73.4	68.4	75.41	7.66	12.00
6MM	0MM	87	85.2	88.4	87.6	88.2	85.6	87.8	91.7	86.5	85.1	86	86.3	87.10	1.84	12.00
	15MM	87	85.2	88.2	87.3	88.2	85.5	86.2	91.7	86.3	84.8	85.9	86	86.86	1.87	12.00
	25MM	86.8	84.7	88.3	87.2	88.2	85.2	86	91.5	86.2	84.3	85.8	86.1	86.69	1.95	12.00
	30MM	86.7	84.8	88.3	87.2	88.1	84.7	86	91.6	86.2	83.6	85.8	85.7	86.56	2.10	12.00
	35MM	86.6	84.3	88.3	87	88	84.3	85.7	91.3	86.2	83	85.7	86	86.37	2.18	12.00
	40MM	86.3	84	88.3	87	87.9	83.8	85.6	91.3	86.8	82.5	85.6	86	86.17	2.32	12.00
	45MM	86.4	83.7	88.3	87	87.8	83.3	85.3	91.2	86.2	81.9	85.5	85.8	85.96	2.48	12.00
	50MM	86.2	83.4	88.2	87.1	87.7	82.6	85.2	91.1	85.1	81.6	85.1	85.9	85.77	2.60	12.00
	55MM	86	83	88.2	86.9	87.7	82.3	83.6	91	84.7	81	85.2	85.8	85.46	2.79	12.00
	60MM	85.5	83	88.1	86.8	87.5	81.5	83	91	84.4	80.2	84.8	85.2	85.08	3.00	12.00
	65MM	85	82.7	88	86.6	87.3	81.1	82.7	90.6	84.1	79.3	84.2	84.5	84.67	3.12	12.00
	70MM	84.5	82.5	87.7	86.5	87.2	80.5	82.3	90.4	83.1	78	84	84.3	84.25	3.37	12.00
	75MM	83.7	82	87.6	86.4	87.1	79.8	82.2	90.2	82.1	77.1	83.7	83.9	83.82	3.69	12.00
	85MM	82.5	81.4	87.5	85.8	86.6	79.4	81.4	89.7	80.8	74.8	82.5	83.5	82.99	4.01	12.00
	100MM	81.1	79.1	86.4	84.1	86.2	78	80	88.8	78.7	71.5	79.2	82.9	81.34	4.70	12.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure A1 (cont.)

LISTING OF VENTILATION FOR INDIVIDUAL CIGARETTES BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES FOR MEDIUM MODULUS

HOLDER 12MM

INSERTION LENGTH	PRESSURE(MM OF HG)	CIGARETTE 1 VENTILATION %	2 VENTILATION %	3 VENTILATION %	4 VENTILATION %	5 VENTILATION %	6 VENTILATION %	7 VENTILATION %	8 VENTILATION %	9 VENTILATION %	10 VENTILATION %	11 VENTILATION %	12 VENTILATION %	AVG.	STD.	N
8MM	0MM	87.5	84.4	89.7	85.2	85.1	88.3	88	91.3	89.6	91.7	84.4	87.2	87.70	2.56	12.00
	15MM	87.3	84.4	89.5	84.8	85.1	88.2	88	91.2	89.6	91.5	84.2	87	87.57	2.57	12.00
	25MM	87.4	84.3	89.4	84.8	85.2	88.2	87.4	91.2	89.4	91.6	84.2	86.8	87.49	2.57	12.00
	30MM	87.2	84.1	89.3	84.7	85	88.2	87.7	91.3	89.3	91.6	84.2	86.8	87.43	2.62	12.00
	35MM	87.1	84.1	89.1	84.6	85.1	88.3	87.5	91.3	89.3	91.6	84.1	86.5	87.38	2.63	12.00
	40MM	87.2	84.3	88.7	84.8	84.9	88.3	87.6	91.2	89.2	91.6	84.2	86.9	87.40	2.53	12.00
	45MM	87.2	84.4	88.5	84.6	84.8	88.1	87.6	91.1	88.9	91.2	84.2	86.7	87.27	2.46	12.00
	50MM	87	84.4	88.2	84.4	84.7	88.1	87.5	91	88.1	91.3	84.2	86.6	87.12	2.44	12.00
	55MM	86.9	84.4	88.4	84.8	84.7	88	87.4	91	88	91.1	84.1	86.4	87.10	2.38	12.00
	60MM	86.9	84.3	88	85	84.3	87.9	87.3	91	87.8	91	84	86.2	86.97	2.39	12.00
	65MM	86.9	84.1	87.8	85	84.5	87.7	87.3	90.9	87.4	90.4	83.8	86	86.82	2.29	12.00
	70MM	86.8	84.3	87.8	85	84.2	87.4	87.3	90.8	87	89.8	83.6	85.8	86.65	2.21	12.00
	75MM	86.7	84.2	87.7	84.8	84.2	87.3	87	90.7	86.5	89.4	83.4	85.5	86.45	2.18	12.00
	85MM	86.4	83.3	87.6	84.7	83.9	86.4	86.7	90.7	86.1	89.3	82.4	85.1	86.06	2.40	12.00
	100MM	86.1	82.3	87.4	84.3	83.4	84.7	85.1	90.4	81.4	88.5	81.2	84.4	84.93	2.80	12.00
10MM	0MM	85.4	88.9	82.7	88	91	85.3	86.2	84.2	83.6	86.3	84.1	87.4	86.09	2.41	12.00
	15MM	85.3	88.9	82.7	87.9	90.9	85	86.1	83.7	83.5	86	83.9	87.4	85.94	2.45	12.00
	25MM	85.6	88.7	82.7	87.6	90.7	84.9	85.9	83.6	83.3	85.7	83.8	87.2	85.81	2.40	12.00
	30MM	85.5	88.8	82.6	87.7	90.6	84.8	85.7	83.4	83.2	85.7	83.7	87	85.72	2.44	12.00
	35MM	85.5	88.7	82.6	87.9	90.8	84.8	85.5	83.3	83	85.5	83.7	86.9	85.68	2.50	12.00
	40MM	85.6	88.7	82.6	87.9	90.7	84.7	85.4	83.1	83.1	85.4	83.8	87.2	85.67	2.51	12.00
	45MM	85.3	88.7	82.5	88.1	90.7	84.7	85.2	83.1	83	85.3	83.7	87.1	85.62	2.55	12.00
	50MM	85.2	88.7	82.4	88.1	90.5	84.5	84.9	83.1	82.8	85.3	83.6	87.1	85.52	2.56	12.00
	55MM	85.2	88.6	82.3	88	90.5	84.5	84.3	82.8	82.7	85.2	83.5	87	85.38	2.81	12.00
	60MM	85.2	88.6	82.3	88	90.4	84.4	84.2	82.8	82.5	84.9	83.5	86.9	85.32	2.81	12.00
	65MM	85.1	88.3	81.9	87.9	90.3	84.3	83.7	82.5	82.5	84.6	83.3	86.7	85.09	2.65	12.00
	70MM	85.2	88	81.8	87.7	90.3	84.2	82.9	82.5	82.5	84.4	83.4	86.9	84.98	2.68	12.00
	75MM	85.2	87.9	81.1	87.1	90.2	84.1	82.6	82.2	82.3	84	83.2	86.8	84.72	2.76	12.00
	85MM	85.1	87.7	79.4	86.1	89.3	83.8	82.1	81.7	81.6	83	82.9	86.8	84.12	2.81	12.00
	100MM	85	87.2	77.8	85.3	88.3	83.4	81.5	81	75.7	81.4	82	86.8	82.93	3.79	12.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure A2 (cont.)

LISTING OF CHANGE IN VENTILATION FOR INDIVIDUAL CIGARETTES
BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES
FOR LOW MODULUS
NOTE: CHANGE = INITIAL - OTHERS FOR EACH CIGARETTE

HOLDER 12MM

		CIGARETTE 1	2	3	4	5	6	7	8	9	10	11	12			
		CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	AVG.	STD.	N
INSERTION LENGTH	PRESSURE(MM OF HG)															
4MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.30	0.30	0.10	0.10	0.40	0.80	0.60	0.30	0.50	1.90	0.20	0.20	0.48	0.49	12.00
	25MM	0.70	0.40	0.40	0.40	2.20	1.20	1.20	1.10	0.90	2.50	1.00	0.50	1.04	0.69	12.00
	30MM	1.00	0.40	0.70	0.80	3.70	1.40	1.20	1.50	1.40	3.60	2.00	0.80	1.54	1.07	12.00
	35MM	1.60	0.40	1.10	1.40	5.40	2.20	1.30	2.50	1.90	4.80	3.40	2.10	2.34	1.50	12.00
	40MM	1.90	0.10	1.50	1.80	7.20	3.10	1.60	3.70	2.70	6.30	5.40	3.10	3.20	2.13	12.00
	45MM	2.60	-.10	2.40	2.20	8.80	4.20	1.70	4.40	3.40	9.30	8.60	3.10	4.22	3.06	12.00
	50MM	2.80	-.10	2.90	2.50	10.4	5.50	1.80	5.30	4.00	11.8	10.2	3.90	5.08	3.77	12.00
	55MM	3.30	0.10	3.40	2.90	12.8	6.50	1.90	5.90	4.60	15.2	11	4.50	6.01	4.63	12.00
	60MM	3.80	0.30	3.80	3.70	14.8	7.80	2.20	6.80	5.40	18.3	12.3	5.10	7.02	5.42	12.00
	65MM	4.40	0.30	4.40	4.50	16.7	8.70	2.60	7.10	5.90	21.6	13.6	6.00	7.98	6.24	12.00
	70MM	4.80	0.50	5.10	5.20	19.4	9.80	2.70	7.80	6.50	25.5	14.9	6.70	9.07	7.31	12.00
	75MM	5.30	0.50	5.90	5.70	21.2	11	2.90	8.30	7.40	28	15.8	7.30	9.94	7.97	12.00
	85MM	6.40	0.80	7.40	7.00	25.5	14.3	3.60	9.10	8.50	31.9	18.4	8.50	11.87	9.17	12.00
	100MM	7.70	1.40	10.2	9.70	30.3	17.6	4.70	11.5	10.1	37.7	20.7	12.4	14.50	10.55	12.00
6MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.20	0.20	0.10	0.20	0.20	0.20	0.00	-.10	0.00	0.30	0.20	0.00	0.13	0.12	12.00
	25MM	0.20	0.00	0.30	0.30	0.30	0.50	0.00	-.10	0.60	0.60	0.70	0.10	0.29	0.26	12.00
	30MM	0.40	0.10	0.60	0.20	0.40	0.60	0.20	-.10	0.90	1.00	0.70	0.10	0.42	0.34	12.00
	35MM	0.50	0.20	1.00	0.40	0.60	1.00	0.10	-.10	1.10	1.40	1.90	0.20	0.69	0.60	12.00
	40MM	0.60	0.60	1.70	0.50	0.90	1.90	0.20	0.00	1.40	2.40	2.10	0.20	1.04	0.82	12.00
	45MM	0.70	0.90	2.60	0.80	1.60	2.40	0.30	0.20	1.70	2.90	2.30	0.30	1.39	0.98	12.00
	50MM	0.80	1.50	3.30	1.50	2.00	3.60	0.40	0.40	1.70	3.60	2.80	0.30	1.82	1.26	12.00
	55MM	1.00	1.70	4.50	2.20	2.50	4.80	0.70	0.80	2.30	4.00	2.90	0.50	2.32	1.49	12.00
	60MM	1.40	3.00	6.80	2.60	3.20	6.40	1.20	1.40	2.80	4.60	3.00	0.60	3.08	1.97	12.00
	65MM	2.20	4.20	9.20	3.00	4.00	7.30	2.00	2.00	3.40	5.30	3.20	0.70	3.88	2.40	12.00
	70MM	3.20	4.90	10.4	3.20	4.60	8.70	2.60	.	4.00	6.20	3.40	0.80	4.72	2.78	11.00
	75MM	3.70	5.60	11.4	3.90	4.90	9.90	3.00	2.60	4.80	6.60	3.60	0.80	5.07	3.02	12.00
	85MM	4.80	7.10	14.4	5.00	6.20	13.1	3.90	3.40	5.90	7.80	4.20	2.30	6.51	3.73	12.00
	100MM	5.70	9.30	19.2	6.90	7.90	18	16.9	4.80	7.10	10.7	5.50	2.90	9.57	5.51	12.00

(CONTINUED)

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Figure A2 (cont.)

LISTING OF CHANGE IN VENTILATION FOR INDIVIDUAL CIGARETTES
BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES
FOR LOW MODULUS
NOTE: CHANGE = INITIAL - OTHERS FOR EACH CIGARETTE

HOLDER 12MM

INSERTION LENGTH	PRESSURE(MM OF HG)	CIGARETTE 1 CHG IN VEN-T. %	2 CHG IN VEN-T. %	3 CHG IN VEN-T. %	4 CHG IN VEN-T. %	5 CHG IN VEN-T. %	6 CHG IN VEN-T. %	7 CHG IN VEN-T. %	8 CHG IN VEN-T. %	9 CHG IN VEN-T. %	10 CHG IN VEN-T. %	11 CHG IN VEN-T. %	12 CHG IN VEN-T. %	AVG.	STD.	N
8MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.30	0.10	0.00	0.00	0.10	0.20	0.00	0.20	-.50	-.10	0.10	0.20	0.05	0.21	12.00
	25MM	1.00	0.20	-1	0.10	0.20	0.10	0.00	0.20	-.40	0.00	0.80	0.10	0.11	0.51	12.00
	30MM	1.70	0.20	-.20	0.10	0.10	0.40	0.10	0.50	-.20	0.10	1.10	0.20	0.34	0.55	12.00
	35MM	1.70	0.30	0.00	0.20	0.10	0.40	0.20	0.70	-.30	0.30	0.30	0.20	0.34	0.49	12.00
	40MM	1.80	0.50	-.10	0.00	0.00	0.50	0.20	1.00	-.30	0.20	0.40	0.40	0.38	0.56	12.00
	45MM	2.00	0.40	0.00	0.10	0.20	0.50	0.50	1.60	0.00	0.20	0.30	0.60	0.53	0.63	12.00
	50MM	2.50	0.50	0.10	0.30	0.40	0.70	0.90	1.90	0.00	0.30	0.30	1.00	0.74	0.76	12.00
	55MM	2.10	0.50	0.10	0.50	0.40	1.20	1.30	2.60	0.30	0.50	0.40	2.00	0.99	0.83	12.00
	60MM	2.50	0.50	0.20	0.70	0.50	1.50	1.40	2.70	0.60	0.70	0.60	2.40	1.18	0.89	12.00
	65MM	3.00	0.50	0.20	0.80	0.70	1.90	1.70	3.00	0.80	1.10	0.70	2.50	1.42	0.98	12.00
	70MM	3.30	0.60	0.30	0.90	1.70	2.10	1.80	3.50	1.50	1.30	1.00	2.80	1.73	1.03	12.00
	75MM	3.80	0.80	0.20	1.10	1.70	2.40	2.00	3.90	2.20	2.40	1.30	3.10	2.07	1.15	12.00
	85MM	4.50	1.00	0.60	1.60	2.50	3.30	2.30	4.60	4.20	3.20	2.20	3.60	2.78	1.35	12.00
	100MM	5.80	1.40	0.70	2.40		4.30	3.60	5.80	7.40	4.80	3.40	4.40	4.00	1.99	11.00
10MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.20	0.00	0.10	0.10	0.00	0.00	0.10	-.40	0.00	0.10	-.10	0.00	0.01	0.15	12.00
	25MM	0.20	0.00	0.00	0.10	0.10	-.10	0.00	-.10	0.10	-.10	-.10	0.30	0.03	0.13	12.00
	30MM	0.20	-.10	-.10	0.10	0.10	-.10	0.00	-.20	0.10	0.10	-.10	0.20	0.02	0.13	12.00
	35MM	0.20	-.10	-.10	0.30	0.20	0.00	0.20	0.00	0.10	0.30	0.00	0.40	0.13	0.17	12.00
	40MM	0.20	0.00	-.10	0.40	0.00	0.00	0.40	-.10	0.10	0.60	-.10	0.40	0.14	0.23	12.00
	45MM	0.20	0.10	0.00	0.50	0.00	-.20	0.30	-.10	0.10	0.70	-.10	0.60	0.17	0.28	12.00
	50MM	0.30	-.10	0.00	0.70	0.10	-.10	0.40	-.20	0.00	0.80	-.10	0.70	0.21	0.36	12.00
	55MM	0.30	0.00	-.10	0.60	0.30	0.00	0.50	-.20	0.00	1.10	-.20	0.80	0.26	0.42	12.00
	60MM	0.40	0.00	-.20	1.10	0.50	0.10	0.80	-.10	0.20	1.40	0.30	1.00	0.46	0.61	12.00
	65MM	0.40	0.00	-.10	1.20	0.90	0.20	0.80	-.10	0.10	1.70	0.30	1.10	0.54	0.59	12.00
	70MM	0.40	0.20	-.10	1.30	1.50	0.20	1.00	-.10	0.20	2.30	0.10	1.30	0.69	0.77	12.00
	75MM	0.50	0.10	-.20	1.70	2.20	0.20	1.30	-.10	0.20	3.10	0.20	1.40	0.88	1.05	12.00
	85MM	1.60	0.30	-.10	3.30	2.60	0.70	2.00	-.10	0.20	7.10	0.30	2.10	1.67	2.05	12.00
	100MM	2.40	1.30	-.10	4.80	3.60	1.60	3.50	0.10	0.10	9.60	0.40	2.80	2.50	2.76	12.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure A2 (cont.)

LISTING OF CHANGE IN VENTILATION FOR INDIVIDUAL CIGARETTES
BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES
FOR MEDIUM MODULUS
NOTE: CHANGE = INITIAL - OTHERS FOR EACH CIGARETTE

HOLDER 12MM

		CIGARETTE 1	2	3	4	5	6	7	8	9	10	11	12			
		CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	AVG.	STD.	N
INSERTION LENGTH	PRESSURE(MM OF HG)															
4MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.20	0.30	0.10	0.10	0.40	0.60	.	0.40	0.30	0.00	0.40	0.10	0.26	0.18	11.00
	25MM	0.10	0.80	0.20	0.30	0.70	0.90	.	0.60	1.00	0.00	0.40	0.60	0.51	0.33	11.00
	30MM	0.20	1.60	0.20	0.50	1.20	1.30	.	0.90	1.50	0.30	0.40	1.30	0.85	0.55	11.00
	35MM	0.00	3.40	0.20	0.40	1.40	1.30	.	1.00	2.10	0.60	0.50	3.00	1.26	1.13	11.00
	40MM	-.20	4.60	0.50	0.50	1.60	1.30	.	1.40	2.70	0.80	0.60	4.30	1.65	1.58	11.00
	45MM	0.00	6.10	0.80	0.60	1.70	1.50	.	1.60	3.90	1.10	0.90	5.20	2.13	2.01	11.00
	50MM	-.10	7.40	1.10	0.60	1.90	1.60	.	1.90	5.20	1.50	1.50	6.30	2.63	2.48	11.00
	55MM	0.20	8.30	1.50	1.00	2.00	1.70	.	2.30	5.90	1.90	1.90	8.10	3.16	2.86	11.00
	60MM	0.80	9.50	2.10	1.50	2.30	2.10	.	3.10	6.50	2.80	2.50	9.40	3.87	3.11	11.00
	65MM	1.20	10.7	2.70	1.70	2.60	2.40	.	3.50	7.10	3.30	2.50	10.4	4.37	3.41	11.00
	70MM	3.00	12.3	3.60	2.00	2.80	3.30	.	3.60	7.40	3.70	3.50	11.4	5.16	3.58	11.00
	75MM	3.40	13.7	4.00	2.20	3.00	3.70	.	4.10	7.80	4.40	4.80	12.4	5.77	3.87	11.00
	85MM	4.80	17.5	5.30	3.10	3.80	4.60	.	5.60	9.30	5.30	8.10	15	7.48	4.71	11.00
	100MM	6.20	22.8	6.90	5.20	5.10	5.80	.	7.20	12.1	7.80	11.1	19.6	8.98	6.03	11.00
6MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.00	0.00	0.20	0.20	0.00	0.00	1.60	0.00	0.20	0.30	0.10	0.30	0.24	0.44	12.00
	25MM	0.20	0.50	0.10	0.30	0.00	0.30	1.80	0.20	0.30	0.80	0.20	0.20	0.41	0.48	12.00
	30MM	0.30	0.40	0.10	0.30	0.10	0.80	1.80	0.10	0.30	1.50	0.20	0.60	0.54	0.56	12.00
	35MM	0.40	0.90	0.10	0.50	0.20	1.20	2.10	0.40	0.30	2.10	0.30	0.30	0.73	0.71	12.00
	40MM	0.70	1.20	0.10	0.50	0.30	1.70	2.20	0.40	0.70	2.60	0.40	0.30	0.93	0.82	12.00
	45MM	0.60	1.50	0.10	0.50	0.40	2.20	2.50	0.50	1.30	3.20	0.50	0.50	1.15	1.00	12.00
	50MM	0.80	1.80	0.20	0.40	0.50	2.90	2.60	0.60	1.40	3.50	0.90	0.40	1.33	1.12	12.00
	55MM	1.00	2.20	0.20	0.60	0.50	3.20	4.20	0.70	1.80	4.10	0.80	0.50	1.65	1.45	12.00
	60MM	1.50	2.20	0.30	0.70	0.70	4.00	4.80	0.70	2.10	4.90	1.20	1.10	2.02	1.65	12.00
	65MM	2.00	2.50	0.40	0.90	0.90	4.40	5.10	1.10	2.40	5.80	1.80	1.80	2.42	1.76	12.00
	70MM	2.50	2.70	0.70	1.00	1.00	5.00	5.50	1.30	3.40	7.10	2.00	2.00	2.85	2.03	12.00
	75MM	3.30	3.20	0.80	1.10	1.10	5.60	5.60	1.50	4.40	8.00	2.30	2.40	3.27	2.23	12.00
	85MM	4.50	3.80	0.90	1.70	1.60	6.10	6.40	2.00	5.70	10.3	3.50	2.80	4.11	2.68	12.00
	100MM	5.90	6.10	2.00	3.40	2.00	7.50	7.80	2.80	7.80	13.8	5.80	3.40	5.76	3.33	12.00

(CONTINUED)

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Figure A2 (cont.)

LISTING OF CHANGE IN VENTILATION FOR INDIVIDUAL CIGARETTES
BY HOLDER LENGTHS, INSERTION LENGTHS AND PRESSURES
FOR MEDIUM MODULUS
NOTE: CHANGE = INITIAL - OTHERS FOR EACH CIGARETTE

HOLDER 12MM

		CIGARETTE														
		1	2	3	4	5	6	7	8	9	10	11	12			
		CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	CHG IN VEN-T. %	AVG.	STD.	N
INSERTION LENGTH	PRESSURE(MM OF HG)															
8MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.20	0.00	0.20	0.40	0.00	0.10	0.00	0.10	0.00	0.20	0.20	0.20	0.13	0.12	12.00
	25MM	0.10	0.10	0.30	0.40	-.10	0.10	0.60	0.10	0.20	0.10	0.20	0.40	0.21	0.19	12.00
	30MM	0.30	0.30	0.40	0.60	0.10	0.10	0.30	0.00	0.30	0.10	0.20	0.60	0.27	0.18	12.00
	35MM	0.40	0.30	0.60	0.60	0.00	0.00	0.60	0.00	0.30	0.10	0.30	0.70	0.32	0.25	12.00
	40MM	0.30	0.10	1.00	0.40	0.20	0.00	0.40	0.10	0.40	0.20	0.20	0.30	0.30	0.26	12.00
	45MM	0.30	0.00	1.20	0.60	0.30	0.20	0.40	0.20	0.70	0.50	0.20	0.50	0.43	0.31	12.00
	50MM	0.50	0.00	1.60	0.80	0.40	0.20	0.50	0.30	1.50	0.40	0.20	0.60	0.57	0.48	12.00
	55MM	0.60	0.00	1.30	0.40	0.40	0.30	0.60	0.30	1.60	0.60	0.30	0.80	0.60	0.45	12.00
	60MM	0.60	0.10	1.70	0.20	0.80	0.40	0.70	0.30	1.80	0.70	0.40	1.00	0.72	0.54	12.00
	65MM	0.60	0.30	1.90	0.20	0.60	0.60	0.70	0.40	2.20	1.30	0.60	1.20	0.88	0.64	12.00
	70MM	0.70	0.10	1.90	0.20	0.90	0.90	0.70	0.50	2.60	1.90	0.80	1.40	1.06	0.75	12.00
	75MM	0.80	0.20	2.00	0.40	0.90	1.00	1.00	0.60	3.10	2.30	1.00	1.70	1.26	0.86	12.00
	85MM	1.10	1.10	2.10	0.50	1.20	1.90	1.30	0.60	3.50	2.40	2.00	2.10	1.66	0.85	12.00
	100MM	1.40	2.10	2.30	0.90	1.70	3.60	2.90	0.90	8.20	3.20	3.20	2.80	2.77	1.84	12.00
10MM	0MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00
	15MM	0.10	0.00	0.00	0.10	0.10	0.30	0.10	0.50	0.10	0.30	0.20	0.00	0.15	0.15	12.00
	25MM	-.20	0.20	0.00	0.40	0.30	0.40	0.30	0.60	0.30	0.60	0.30	0.20	0.28	0.22	12.00
	30MM	-.10	0.10	0.10	0.30	0.40	0.50	0.50	0.80	0.40	0.60	0.40	0.40	0.37	0.24	12.00
	35MM	-.10	0.20	0.10	0.10	0.20	0.50	0.70	0.90	0.60	0.80	0.40	0.50	0.41	0.31	12.00
	40MM	-.10	0.20	0.10	0.10	0.30	0.60	0.80	1.10	0.50	0.90	0.30	0.20	0.42	0.37	12.00
	45MM	0.10	0.20	0.20	-.10	0.30	0.60	1.00	1.10	0.60	1.00	0.40	0.30	0.47	0.39	12.00
	50MM	0.20	0.20	0.30	-.10	0.50	0.80	1.30	1.10	0.80	1.00	0.50	0.30	0.58	0.42	12.00
	55MM	0.20	0.30	0.40	0.00	0.60	0.80	1.90	1.40	0.90	1.10	0.60	0.40	0.71	0.55	12.00
	60MM	0.20	0.30	0.40	0.00	0.60	0.90	2.00	1.30	1.10	1.40	0.60	0.50	0.77	0.58	12.00
	65MM	0.30	0.60	0.80	0.10	0.70	1.00	2.50	1.70	1.10	1.70	0.80	0.70	1.00	0.67	12.00
	70MM	0.20	0.90	0.90	0.30	0.70	1.10	3.30	1.70	1.10	1.90	0.70	0.50	1.11	0.86	12.00
	75MM	0.20	1.00	1.60	0.90	0.80	1.20	3.60	2.00	1.30	2.30	0.90	0.60	1.37	0.91	12.00
	85MM	0.30	1.20	3.30	1.90	1.70	1.50	4.10	2.50	2.00	3.30	1.20	0.60	1.97	1.15	12.00
	100MM	0.40	1.70	4.90	2.70	2.70	1.90	4.70	3.20	7.90	4.90	2.10	0.80	3.16	2.12	12.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

APPENDIX B

SMOKING DATA

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure B1

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=TAR(MG/CIG)

MODULUS LOW

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	AVG	STD	N
4MM	35MM	0.70	0.70	0.80	1.00	0.40	0.70	0.72	0.19	6.00
	60MM	0.80	0.60	1.60	0.60	0.90	0.70	0.85	0.39	6.00
	85MM	1.20	1.20	2.20	1.10	1.20	1.80	1.45	0.46	6.00
6MM	35MM	0.70	0.80	0.80	0.80	0.80	0.80	0.78	0.04	6.00
	60MM	0.60	0.90	0.60	0.60	0.90	1.20	0.80	0.24	6.00
	85MM	2.10	1.30	1.20	1.20	1.60	1.60	1.47	0.34	6.00
8MM	35MM	0.40	0.70	0.70	0.70	0.80	0.60	0.63	0.15	6.00
	60MM	0.70	0.60	0.70	0.70	0.60	0.90	0.70	0.11	6.00
	85MM	1.00	0.90	1.00	1.00	0.90	1.10	0.98	0.08	6.00

MODULUS MEDIUM

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	AVG	STD	N
4MM	35MM	0.80	0.90	0.60	1.10	0.60	1.00	0.82	0.23	6.00
	60MM	1.20	1.00	1.00	0.30	0.30	0.60	0.72	0.40	6.00
	85MM	1.60	2.30	1.30	1.00	0.80	1.10	1.36	0.64	6.00
6MM	35MM	0.60	0.60	0.60	0.80	0.70	0.60	0.60	0.13	6.00
	60MM	0.90	0.80	0.60	0.60	1.00	0.40	0.70	0.24	6.00
	85MM	0.90	1.20	1.40	1.20	1.20	0.90	1.13	0.20	6.00
8MM	35MM	0.80	0.70	0.60	0.60	0.60	0.40	0.68	0.16	6.00
	60MM	0.60	0.20	0.70	0.60	0.80	0.70	0.68	0.21	6.00
	85MM	0.60	0.80	1.10	0.80	1.30	0.80	0.85	0.21	6.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure B1 (cont.)

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=NICOTINE(MG/CIG)

MODULUS LOW

		REPLICATES								
		1	2	3	4	5	6			
		RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	AVG	STD	N
INSERTION LENGTH	PRESSURE(MM OF HG)									
4MM	35MM	0.09	0.09	0.08	0.11	0.07	0.10	0.09	0.01	6.00
	60MM	0.10	0.09	0.19	0.08	0.11	0.09	0.11	0.04	6.00
	85MM	0.14	0.16	0.26	0.13	0.16	0.23	0.18	0.05	6.00
6MM	35MM	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.00	6.00
	60MM	0.10	0.12	0.08	0.08	0.12	0.14	0.11	0.02	6.00
	85MM	0.27	0.16	0.16	0.16	0.19	0.17	0.18	0.05	6.00
8MM	35MM	0.05	0.06	0.07	0.09	0.11	0.06	0.07	0.02	6.00
	60MM	0.10	0.08	0.09	0.11	0.09	0.11	0.10	0.01	6.00
	85MM	0.13	0.12	0.12	0.15	0.11	0.15	0.13	0.02	6.00

MODULUS MEDIUM

		REPLICATES								
		1	2	3	4	5	6			
		RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	AVG	STD	N
INSERTION LENGTH	PRESSURE(MM OF HG)									
4MM	35MM	0.10	0.10	0.06	0.14	0.07	0.11	0.10	0.03	6.00
	60MM	0.14	0.14	0.15	0.07	0.13	0.07	0.12	0.04	6.00
	85MM	0.18	0.25	0.16	0.13	0.09	0.11	0.15	0.06	6.00
6MM	35MM	0.07	0.06	0.07	0.09	0.04	0.06	0.06	0.02	6.00
	60MM	0.10	0.10	0.09	0.07	0.12	0.07	0.09	0.02	6.00
	85MM	0.12	0.13	0.17	0.15	0.14	0.10	0.13	0.02	6.00
8MM	35MM	0.09	0.08	0.07	0.08	0.07	0.06	0.07	0.01	6.00
	60MM	0.07	0.04	0.09	0.09	0.11	0.09	0.08	0.02	6.00
	85MM	0.10	0.11	0.13	0.10	0.12	0.11	0.11	0.01	6.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure B1 (cont.)

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=CO(MG/CIG)

MODULUS LOW

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	7 RESULT	8 RESULT	9 RESULT	10 RESULT	11 RESULT	12 RESULT	AVG	STD	N
4MM	35MM	0.10	0.40	0.40	0.30	0.30	0.20	0.30	0.50	0.10	0.30	0.40	0.20	0.29	0.12	12.00
	60MM	0.20	0.70	0.40	0.20	1.00	1.00	0.30	0.20	0.30	0.90	0.60	0.20	0.60	0.32	12.00
	85MM	0.80	0.20	0.90	0.80	2.40	1.00	0.20	0.80	0.60	0.40	1.30	1.00	0.87	0.59	12.00
6MM	35MM	0.30	0.20	0.30	0.30	0.30	0.30	0.30	0.40	0.50	0.30	0.30	0.60	0.34	0.11	12.00
	60MM	0.40	0.60	0.60	0.30	0.40	0.20	0.20	0.60	0.60	0.60	0.60	0.60	0.46	0.15	12.00
	85MM	2.00	0.40	0.20	1.10	0.70	0.60	1.00	0.20	1.00	0.90	1.40	0.70	0.85	0.51	12.00
8MM	35MM	0.20	0.60	0.20	0.40	0.20	0.30	0.40	0.30	0.40	0.30	0.10	0.20	0.30	0.13	12.00
	60MM	0.30	0.40	0.30	0.30	0.30	0.30	0.60	0.60	0.60	0.40	0.60	0.60	0.42	0.12	12.00
	85MM	0.60	0.60	0.60	0.60	0.60	0.30	0.30	1.00	0.70	0.60	0.80	0.70	0.60	0.20	12.00

MODULUS MEDIUM

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	7 RESULT	8 RESULT	9 RESULT	10 RESULT	11 RESULT	12 RESULT	AVG	STD	N
4MM	35MM	0.60	0.30	0.30	0.60	0.10	0.30	0.60	0.40	0.30	0.20	0.60	0.60	0.39	0.17	12.00
	60MM	0.60	0.80	0.60	0.30	0.60	0.60	0.00	0.60	0.80	0.40	0.30	0.30	0.48	0.24	12.00
	85MM	1.10	1.00	1.30	1.70	0.90	1.00	0.60	0.40	0.40	0.30	0.60	0.60	0.81	0.43	12.00
6MM	35MM	0.30	0.30	0.30	0.30	0.30	0.30	0.20	0.50	0.40	0.30	0.20	0.10	0.29	0.10	12.00
	60MM	0.60	0.60	0.60	0.60	0.60	0.30	0.40	0.20	0.30	1.30	0.20	0.20	0.46	0.30	12.00
	85MM	0.60	0.60	0.60	1.00	1.00	0.60	0.60	0.60	0.60	0.80	0.40	0.40	0.60	0.20	12.00
8MM	35MM	0.60	0.30	0.60	0.30	0.30	0.30	0.30	0.20	0.40	0.10	0.20	0.10	0.31	0.16	12.00
	60MM	.	0.20	0.10	0.30	0.60	0.60	0.60	0.30	1.10	0.30	0.30	0.30	0.40	0.26	11.00
	85MM	0.60	0.90	0.30	0.90	0.60	0.60	0.40	0.30	0.80	0.60	0.20	0.40	0.54	0.24	12.00

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Figure B1 (cont.)

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE-FILTER NICOTINE(MG/CIG)

MODULUS LOW

		REPLICATES								
		1	2	3	4	5	6			
		RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	AVG	STD	N
INSERTION LENGTH	PRESSURE(MM OF HG)									
4MM	35MM	0.30	0.28	0.28	0.32	0.22	0.31	0.29	0.04	6.00
	50MM	0.30	0.30	0.46	0.26	0.29	0.28	0.32	0.07	6.00
	85MM	0.35	0.41	0.64	0.44	0.41	0.54	0.46	0.08	6.00
6MM	35MM	0.30	0.32	0.30	0.26	0.33	0.34	0.31	0.03	6.00
	50MM	0.40	0.34	0.33	0.32	0.37	0.38	0.36	0.03	6.00
	85MM	0.42	0.37	0.38	0.34	0.46	0.48	0.41	0.06	6.00
8MM	35MM	0.26	0.26	0.28	0.32	0.28	0.26	0.28	0.02	6.00
	50MM	0.35	0.31	0.33	0.36	0.30	0.30	0.32	0.03	6.00
	85MM	0.40	0.34	0.35	0.40	0.39	0.36	0.37	0.03	6.00

MODULUS MEDIUM

		REPLICATES								
		1	2	3	4	5	6			
		RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	AVG	STD	N
INSERTION LENGTH	PRESSURE(MM OF HG)									
4MM	35MM	0.30	0.33	0.30	0.40	0.29	0.37	0.33	0.04	6.00
	50MM	0.44	0.39	0.36	0.27	0.32	0.31	0.35	0.06	6.00
	85MM	0.43	0.52	0.46	0.36	0.30	0.40	0.41	0.08	6.00
6MM	35MM	0.27	0.25	0.29	0.28	0.32	0.24	0.27	0.03	6.00
	50MM	0.42	0.40	0.37	0.38	0.36	0.28	0.37	0.05	6.00
	85MM	0.33	0.42	0.41	0.35	0.36	0.33	0.37	0.04	6.00
8MM	35MM	0.32	0.34	0.30	0.27	0.26	0.23	0.29	0.04	6.00
	50MM	0.29	0.31	0.38	0.38	0.36	0.32	0.34	0.04	6.00
	85MM	0.39	0.34	0.38	0.27	0.37	0.30	0.34	0.05	6.00

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Figure B1 (cont.)

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=PUFF(/CIG)

MODULUS LOW

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	7 RESULT	8 RESULT	9 RESULT	10 RESULT	11 RESULT	12 RESULT	AVG	STD	N
4MM	35MM	8.20	8.80	8.00	8.40	8.20	8.20	8.10	8.20	8.00	8.70	7.70	8.40	8.24	0.30	12.00
	50MM	8.60	8.80	8.60	8.20	8.40	8.20	8.80	8.50	8.00	7.40	8.70	8.30	8.37	0.40	12.00
	85MM	8.40	8.80	7.80	8.20	7.60	8.20	7.80	7.60	8.00	8.60	8.40	8.40	8.16	0.39	12.00
6MM	35MM	8.20	8.20	8.40	8.00	8.30	8.10	8.20	8.00	8.70	8.30	7.70	8.30	8.20	0.24	12.00
	50MM	7.90	8.40	8.60	9.00	8.00	8.10	8.60	8.00	8.20	8.40	8.40	7.70	8.29	0.38	12.00
	85MM	8.10	8.40	8.20	8.30	8.60	8.30	8.60	8.10	8.20	7.80	8.70	8.40	8.31	0.26	12.00
8MM	35MM	8.40	8.40	8.60	8.60	8.40	8.10	8.10	8.20	8.90	8.40	8.20	8.40	8.38	0.23	12.00
	50MM	8.20	8.80	8.20	8.40	8.40	8.20	8.40	8.40	8.30	8.70	8.40	8.10	8.37	0.21	12.00
	85MM	8.70	8.10	8.80	8.70	8.20	8.10	8.00	8.30	8.50	8.40	8.80	9.00	8.30	0.57	12.00

MODULUS MEDIUM

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	7 RESULT	8 RESULT	9 RESULT	10 RESULT	11 RESULT	12 RESULT	AVG	STD	N
4MM	35MM	8.20	8.10	8.40	7.70	7.80	8.70	8.50	7.90	8.40	8.40	7.80	7.60	8.12	0.36	12.00
	50MM	7.90	8.00	8.10	8.00	7.70	7.50	8.80	8.50	8.50	8.30	8.50	8.20	8.17	0.37	12.00
	85MM	8.20	8.30	7.90	7.80	7.10	8.30	8.70	8.20	8.10	8.20	8.10	8.20	8.09	0.38	12.00
6MM	35MM	8.30	8.20	8.40	8.20	7.90	8.00	8.20	8.60	8.20	8.40	8.80	8.80	8.33	0.28	12.00
	50MM	8.00	7.60	8.40	8.00	8.50	8.10	7.80	8.20	8.40	8.20	8.40	8.60	8.18	0.30	12.00
	85MM	8.50	8.00	8.50	8.80	8.40	8.80	8.80	8.10	8.80	8.70	8.20	8.40	8.50	0.29	12.00
8MM	35MM	6.80	8.30	8.20	8.50	8.60	8.30	8.00	8.60	7.60	8.70	8.00	8.40	8.16	0.52	12.00
	50MM	8.40	7.60	8.00	8.60	8.00	8.60	8.20	8.40	8.00	8.40	7.80	8.40	8.27	0.48	12.00
	85MM	8.80	8.40	8.00	8.10	8.60	8.70	8.00	8.20	8.20	7.50	8.70	8.10	8.36	0.42	12.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure B1 (cont.)

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE-FILTER_EFFICIENCY(%)

MODULUS LOW

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	AVG	STD	N
4MM	35MM	76.9	76.3	77.8	74.4	75.9	75.6	76.15	1.16	6.00
	50MM	75	76.9	70.8	76.6	72.6	76.3	74.67	2.48	6.00
	85MM	71.4	71.9	68.4	77.2	71.9	70.1	71.82	2.96	6.00
6MM	35MM	76.9	78	76.9	72.2	78.6	79.1	76.95	2.49	6.00
	50MM	80	73.9	80.5	80	75.5	73.1	77.17	3.38	6.00
	85MM	60.9	71.2	71.7	68	70.8	73.8	69.40	4.66	6.00
8MM	35MM	83.9	81.3	80	78	71.8	81.3	79.38	4.18	6.00
	50MM	77.8	79.5	78.6	76.6	78.9	73.2	77.10	2.19	6.00
	85MM	75.5	73.9	74.5	72.7	78	70.8	74.20	2.51	6.00

MODULUS MEDIUM

INSERTION LENGTH	PRESSURE(MM OF HG)	REPLICATES 1 RESULT	2 RESULT	3 RESULT	4 RESULT	5 RESULT	6 RESULT	AVG	STD	N
4MM	35MM	75	76.7	83.3	74.1	80.6	77.1	77.80	3.50	6.00
	50MM	75.9	73.6	70.6	79.4	71.1	81.6	75.37	4.46	6.00
	85MM	70.5	67.5	74.2	73.5	76.9	78.4	73.50	4.03	6.00
6MM	35MM	79.4	80.6	80.6	75.7	88.9	82.8	81.33	4.38	6.00
	50MM	80.8	80	80.4	84.4	76	80	80.10	3.00	6.00
	85MM	73.3	76.4	70.7	70	72	76.7	73.18	2.84	6.00
8MM	35MM	78	81	81.1	77.1	79.8	79.3	79.22	1.60	6.00
	50MM	80.6	88.6	80.9	80.9	76.6	78	80.93	4.15	6.00
	85MM	79.6	75.8	74.5	73	76.5	73.2	75.23	2.41	6.00

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure B1 (cont.)

LISTING OF SMOKE ANALYSES FOR INDIVIDUAL PORTS BY MODULUS, INSERTION LENGTHS AND PRESSURES WITH 12MM HOLDER

VARIABLE=H2O(MG/CIG)

MODULUS LOW

		REPLICATES								
		1	2	3	4	5	6			
		RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	AVG	STD	N
INSERTION LENGTH	PRESSURE(MM OF HG)									
4MM	35MM	0.24	0.19	0.08	0.16	0.20	0.17	0.17	0.05	6.00
	60MM	0.16	0.23	0.22	0.16	0.16	0.08	0.17	0.06	6.00
	85MM	0.16	0.23	0.24	0.08	0.15	0.25	0.18	0.07	6.00
6MM	35MM	0.16	0.14	0.12	0.10	0.09	0.13	0.12	0.03	6.00
	60MM	0.27	0.19	0.12	0.15	0.28	0.15	0.19	0.07	6.00
	85MM	0.41	0.20	0.24	0.15	0.18	0.14	0.22	0.10	6.00
8MM	35MM	0.14	0.06	0.09	0.14	0.16	0.06	0.11	0.04	6.00
	60MM	0.20	0.16	0.13	0.28	0.17	0.17	0.18	0.06	6.00
	85MM	0.18	0.14	0.18	0.18	0.13	0.14	0.16	0.02	6.00

MODULUS MEDIUM

		REPLICATES								
		1	2	3	4	5	6			
		RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	RES-ULT	AVG	STD	N
INSERTION LENGTH	PRESSURE(MM OF HG)									
4MM	35MM	0.15	0.15	0.13	0.21	0.18	0.22	0.17	0.04	6.00
	60MM	0.24	0.29	0.28	0.19	0.18	0.15	0.22	0.06	6.00
	85MM	0.15	0.18	0.18	0.22	0.20	0.15	0.18	0.02	6.00
6MM	35MM	0.16	0.12	0.11	0.21	0.14	0.17	0.15	0.04	6.00
	60MM	0.15	0.26	0.22	0.14	0.30	0.19	0.21	0.06	6.00
	85MM	0.18	0.12	0.15	0.16	0.14	0.12	0.14	0.02	6.00
8MM	35MM	0.15	0.16	0.19	0.16	0.30	0.20	0.19	0.06	6.00
	60MM	0.12	0.16	0.21	0.20	0.24	0.13	0.18	0.05	6.00
	85MM	0.18	0.20	0.12	0.19	0.11	0.17	0.16	0.04	6.00

2023100153

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

APPENDIX C

ANALYSES OF VARIANCE FOR SMOKING DATA

2023100154

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C1

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=TAR(MG/CIG)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	8.54268519	0.50251089	6.79	0.0001	0.561981	30.9542
ERROR	90	6.65833333	0.07398148		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	107	15.20101852			0.27199537		0.87870370

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	0.30083333	4.07	0.0467	1	0.30083333	4.07	0.0467
INSET_LG	2	1.14240741	7.72	0.0008	2	1.14240741	7.72	0.0008
MODULUS*INSET_LG	2	0.13722222	0.93	0.3993	2	0.13722222	0.93	0.3993
PRESSURE	2	6.39574074	43.23	0.0001	2	6.39574074	43.23	0.0001
MODULUS*PRESSURE	2	0.05722222	0.39	0.6804	2	0.05722222	0.39	0.6804
INSET_LG*PRESSURE	4	0.37537037	1.27	0.2883	4	0.37537037	1.27	0.2883
MODULO*INSET_*PRESSU	4	0.13388889	0.45	0.7704	4	0.13388889	0.45	0.7704

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0739815

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	0.93148	54	LOW
B	0.82593	54	MEDIUM

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0739815

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	1.2222	36	85
B	0.7250	36	50
B	0.6889	36	35

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0739815

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LG
A	0.98333	36	4
A	0.81389	36	6
B	0.73889	36	8

2023100155

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C2

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=NICOTINE(MG/CIG)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	0.11846296	0.00696841	8.09	0.0001	0.604414	26.6379
ERROR	90	0.07753333	0.00086148		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	107	0.19599630			0.02935100		0.11018519

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	0.00592593	6.88	0.0102	1	0.00592593	6.88	0.0102
INSET_LQ	2	0.01572407	9.13	0.0002	2	0.01572407	9.13	0.0002
MODULUS*INSET_LQ	2	0.00331296	1.92	0.1522	2	0.00331296	1.92	0.1522
PRESSURE	2	0.08500741	49.34	0.0001	2	0.08500741	49.34	0.0001
MODULUS*PRESSURE	2	0.00311852	1.81	0.1696	2	0.00311852	1.81	0.1696
INSET_LQ*PRESSURE	4	0.00428148	1.24	0.2987	4	0.00428148	1.24	0.2987
MODULU*INSET_*PRESSU	4	0.00109259	0.32	0.8659	4	0.00109259	0.32	0.8659

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=8.6E-04

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	0.11759	54	LOW
B	0.10278	54	MEDIUM

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=8.6E-04

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	0.14833	36	85
B	0.10056	36	50
C	0.08167	36	35

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=8.6E-04

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LQ
A	0.12417	36	4
A			
A	0.11167	36	6
B	0.09472	36	8

2023100156

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C3

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=CO(MG/CIG)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	7.13913568	0.41994916	5.42	0.0001	0.318807	56.2816
ERROR	197	15.25416667	0.07743232		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	214	22.39330233			0.27826663		0.49441860

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	0.07743300	1.00	0.3185	1	0.07743300	1.00	0.3185
INSET_LQ	2	0.59702569	3.86	0.0228	2	0.59702569	3.86	0.0228
MODULUS*INSET_LQ	2	0.11224792	0.72	0.4857	2	0.11224792	0.72	0.4857
PRESSURE	2	5.69022569	36.74	0.0001	2	5.69022569	36.74	0.0001
MODULUS*PRESSURE	2	0.19989792	1.29	0.2774	2	0.19989792	1.29	0.2774
INSET_LQ*PRESSURE	4	0.35870806	1.16	0.3306	4	0.35870806	1.16	0.3306
MODULU*INSET_*PRESSU	4	0.10423061	0.34	0.8531	4	0.10423061	0.34	0.8531

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=197 MSE=.0774323

WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES=107.498

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	0.51398	108	LOW
A			
A	0.47670	107	MEDIUM

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=197 MSE=.0774323

WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES=71.6636

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	0.71111	72	85
B	0.45070	71	50
C	0.32083	72	35

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=197 MSE=.0774323

WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES=71.6636

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LQ
A	0.55694	72	4
A			
A	0.49722	72	8
B			
B	0.42817	71	8

2023100157

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C4

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=FILTER_NICOTINE(MG/CIG)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	0.24086667	0.01416863	6.25	0.0001	0.541314	13.8927
ERROR	90	0.20410000	0.00226778		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	107	0.44496667			0.04762119		0.34277778

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	0.00030000	0.13	0.7169	1	0.00030000	0.13	0.7169
INSET_LQ	2	0.02106667	4.64	0.0120	2	0.02106667	4.64	0.0120
MODULUS*INSET_LQ	2	0.00535556	1.18	0.3117	2	0.00535556	1.18	0.3117
PRESSURE	2	0.17111667	37.73	0.0001	2	0.17111667	37.73	0.0001
MODULUS*PRESSURE	2	0.01567222	3.46	0.0358	2	0.01567222	3.46	0.0358
INSET_LQ*PRESSURE	4	0.02263333	2.60	0.0484	4	0.02263333	2.60	0.0484
MODULQ*INSET_*PRESSU	4	0.00472222	0.52	0.7208	4	0.00472222	0.52	0.7208

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0022678

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	0.34444	54	LOW
A			
A	0.34111	54	MEDIUM

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0022678

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	0.39167	36	85
B	0.34250	36	50
C	0.29417	36	35

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0022678

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LQ
A	0.35722	36	4
A			
A	0.34722	36	6
B	0.32389	36	8

2023100158

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C5

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=PUFF(/CIG)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	2.49541667	0.14678922	1.08	0.3763	0.084793	4.4608
ERROR	198	26.93416667	0.13603114		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	215	29.42958333			0.36882400		8.26805556

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	0.13004630	0.96	0.3284	1	0.13004630	0.96	0.3284
INSET_LQ	2	0.63194444	2.32	0.1007	2	0.63194444	2.32	0.1007
MODULUS*INSET_LQ	2	0.40898148	1.50	0.2249	2	0.40898148	1.50	0.2249
PRESSURE	2	0.07694444	0.28	0.7540	2	0.07694444	0.28	0.7540
MODULUS*PRESSURE	2	0.38453704	1.41	0.2458	2	0.38453704	1.41	0.2458
INSET_LQ*PRESSURE	4	0.61944444	1.14	0.3396	4	0.61944444	1.14	0.3396
MODULU*INSET_*PRESSU	4	0.24351852	0.45	0.7741	4	0.24351852	0.45	0.7741

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=198 MSE=0.136031

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	8.2926	108	LOW
A			
A	8.2435	108	MEDIUM

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=198 MSE=0.136031

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	8.2847	72	85
A			
A	8.2778	72	50
A			
A	8.2417	72	35

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=198 MSE=0.136031

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LQ
A	8.3097	72	8
A			
A	8.3028	72	6
A			
A	8.1917	72	4

2023100159

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C6

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=FILTER_EFFICIENCY(%)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	1066.15333333	62.71490196	5.83	0.0001	0.524131	4.2979
ERROR	90	967.98333334	10.75537037		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	107	2034.13666667			3.27953813		76.30555556

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	131.12037037	12.19	0.0007	1	131.12037037	12.19	0.0007
INSET_LG	2	140.69555556	6.54	0.0022	2	140.69555556	6.54	0.0022
MODULUS*INSET_LG	2	30.44740741	1.42	0.2482	2	30.44740741	1.42	0.2482
PRESSURE	2	645.60000000	30.01	0.0001	2	645.60000000	30.01	0.0001
MODULUS*PRESSURE	2	1.29851852	0.06	0.9416	2	1.29851852	0.06	0.9416
INSET_LG*PRESSURE	4	88.05444444	2.05	0.0945	4	88.05444444	2.05	0.0945
MODULU*INSET_*PRESSU	4	29.03703704	0.67	0.6111	4	29.03703704	0.67	0.6111

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=10.7554

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	77.407	54	MEDIUM
B	75.204	54	LOW

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=10.7554

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	78.472	36	35
A			
A	77.556	36	50
B	72.889	36	85

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=10.7554

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LG
A	77.678	36	8
A			
A	76.356	36	6
B	74.883	36	4
B			
B			

2023100160

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

Figure C7

ANALYSES OF VARIANCE FOR SMOKE DELIVERIES

VARIABLE=H2O(MG/CIG)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: RESULT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	17	0.09250463	0.00544145	2.03	0.0171	0.277302	29.7481
ERROR	90	0.24108333	0.00267870		ROOT MSE		RESULT MEAN
CORRECTED TOTAL	107	0.33358796			0.05175619		0.17398148

SOURCE	DF	TYPE III SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MODULUS	1	0.00344537	1.29	0.2598	1	0.00344537	1.29	0.2598
INSET_LQ	2	0.00740185	1.38	0.2564	2	0.00740185	1.38	0.2564
MODULUS*INSET_LQ	2	0.00652407	1.22	0.3007	2	0.00652407	1.22	0.3007
PRESSURE	2	0.02696852	5.03	0.0085	2	0.02696852	5.03	0.0085
MODULUS*PRESSURE	2	0.01857963	3.47	0.0354	2	0.01857963	3.47	0.0354
INSET_LQ*PRESSURE	4	0.00755926	0.71	0.5902	4	0.00755926	0.71	0.5902
MODULU*INSET_*PRESSU	4	0.02202593	2.06	0.0833	4	0.02202593	2.06	0.0833

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0026787

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	MODULUS
A	0.17983	54	MEDIUM
A			
A	0.16833	54	LOW

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0026787

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	PRESSURE
A	0.19250	36	50
A			
B A	0.17556	36	85
B			
B	0.16389	36	35

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE: RESULT
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
NOT THE EXPERIMENTWISE ERROR RATE.

ALPHA=0.05 DF=90 MSE=.0026787

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

DUNCAN GROUPING	MEAN	N	INSET_LQ
A	0.18417	36	4
A			
A	0.17389	36	6
A			
A	0.16389	36	8

2023100161

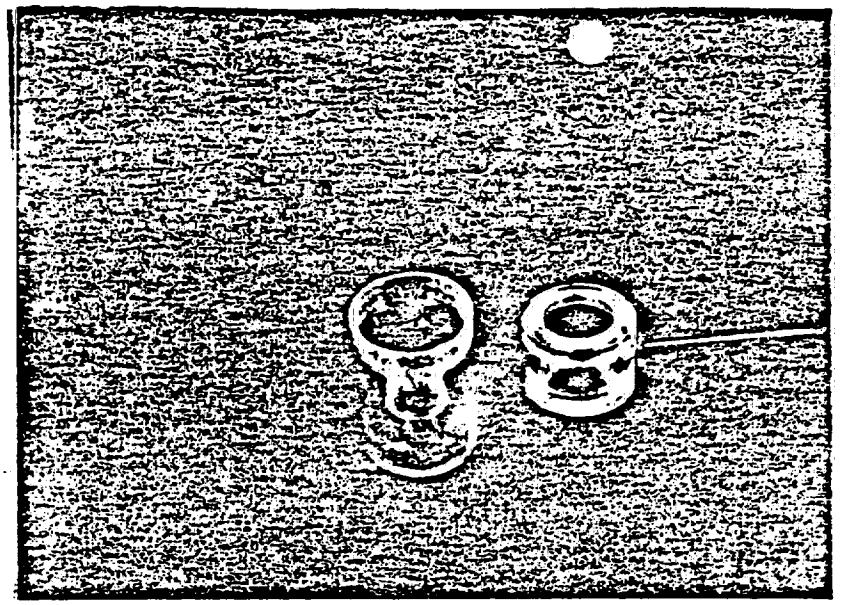
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

APPENDIX D

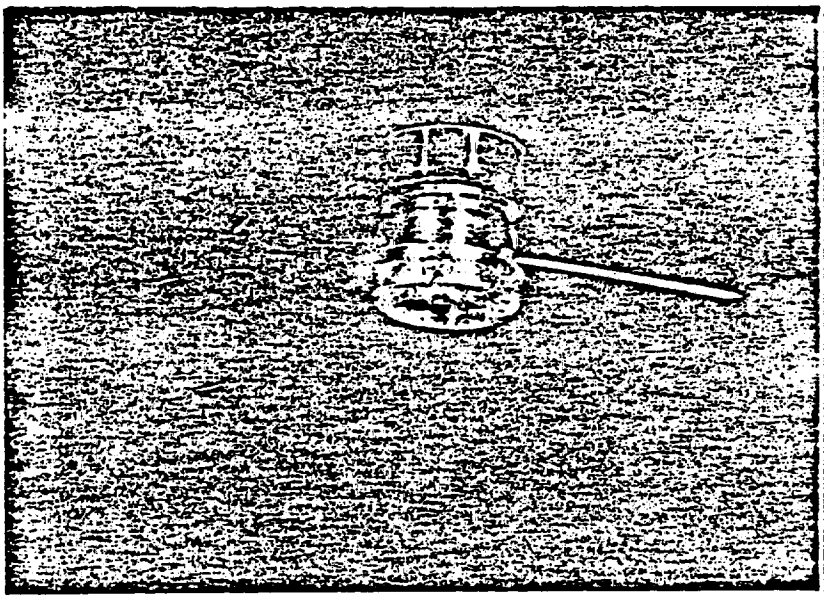
PHOTO DOCUMENTATION

2023100162

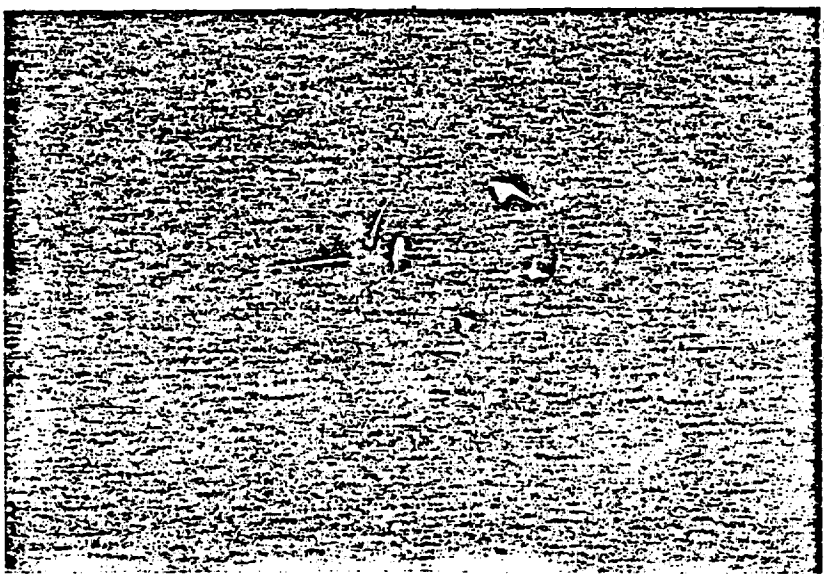
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000



1a. Kamm holder components: O-rings, Kamm tube, and Kamm holder



1b. Partially assembled Kamm holder



1c. Fully assembled Kamm holder

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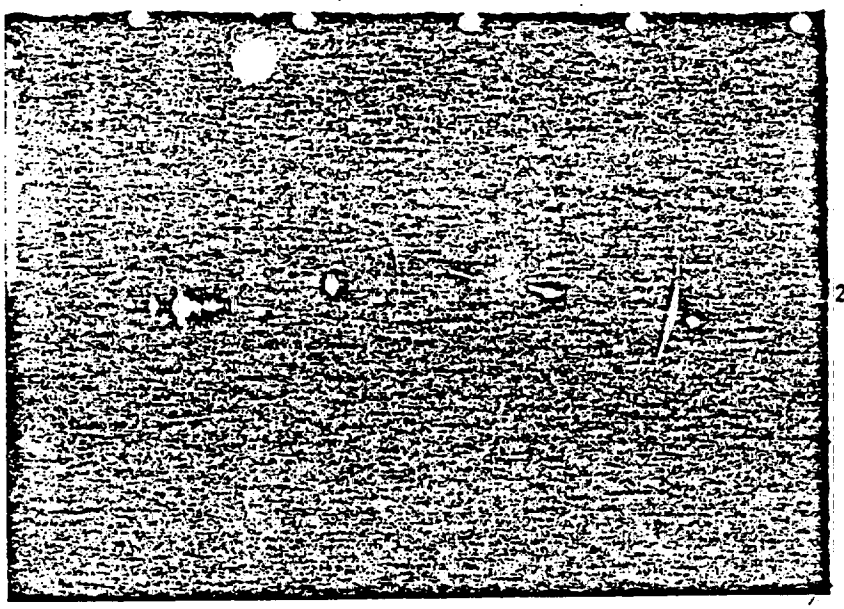
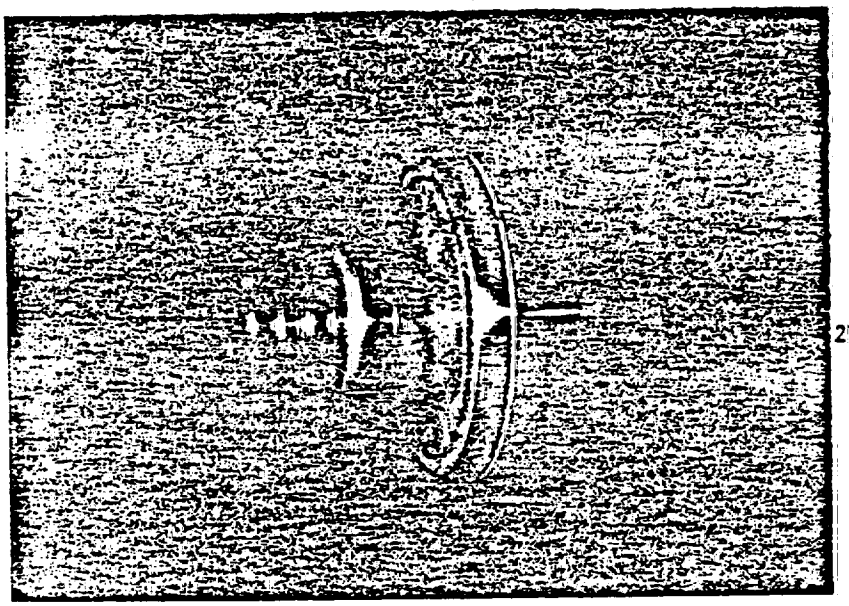
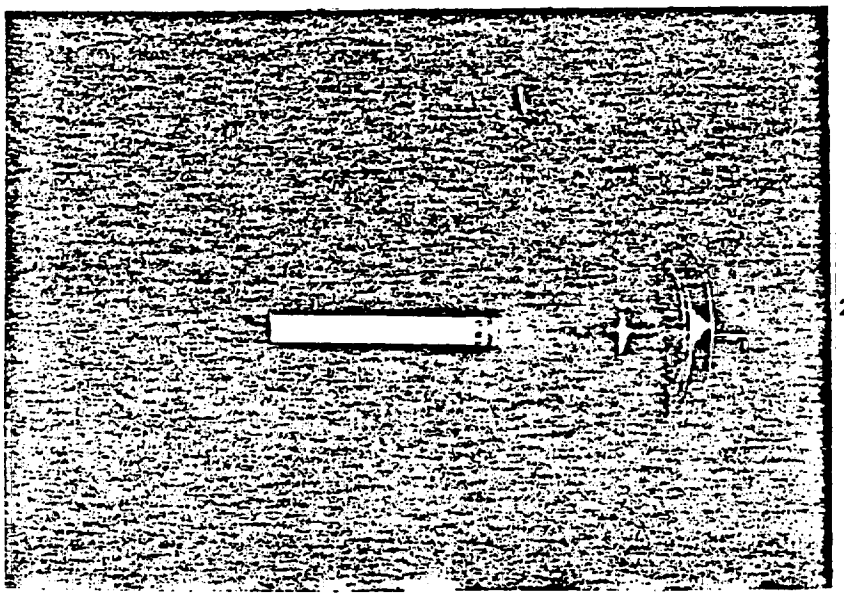


2a. Assembled Kamm holder, adapter collar, and Gelman filter



2b. Fully assembled Kamm holder and Gelman filter



2c. Assembled Kamm holder and Gelman filter with cigarette

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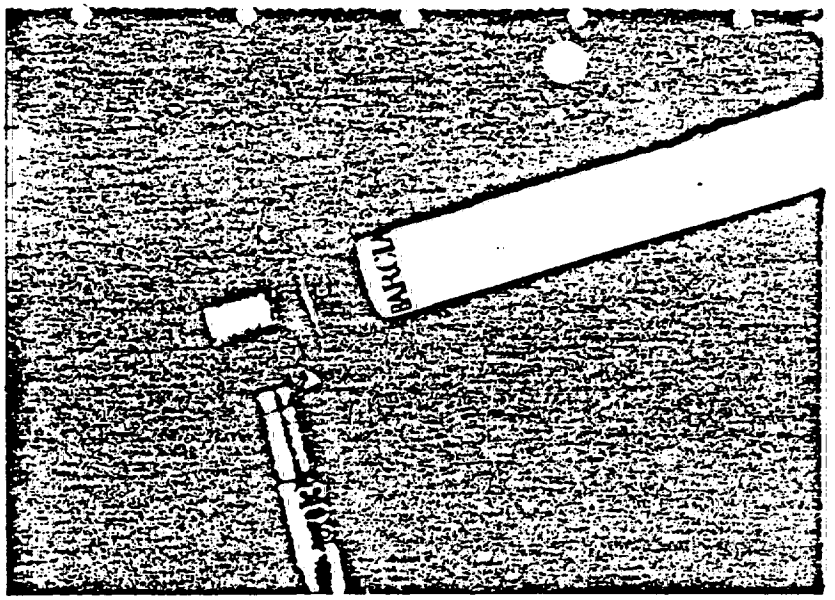
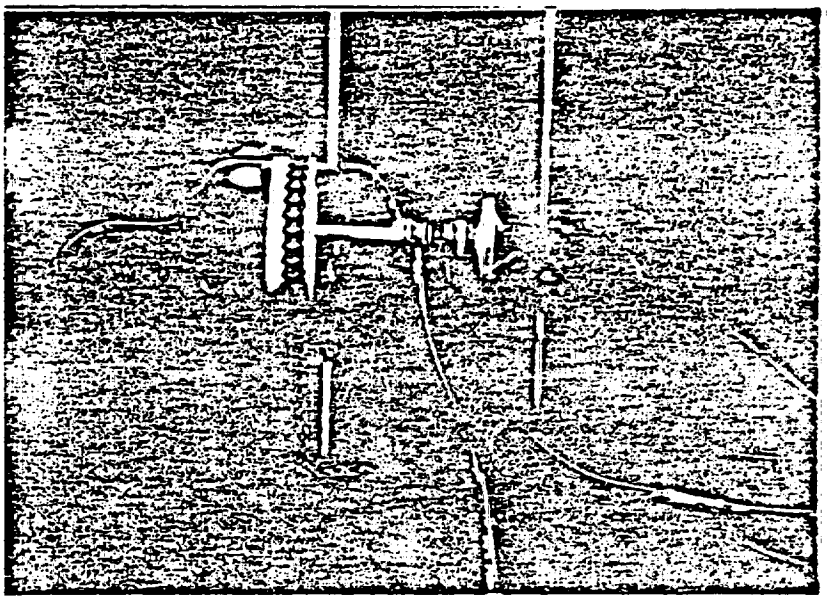
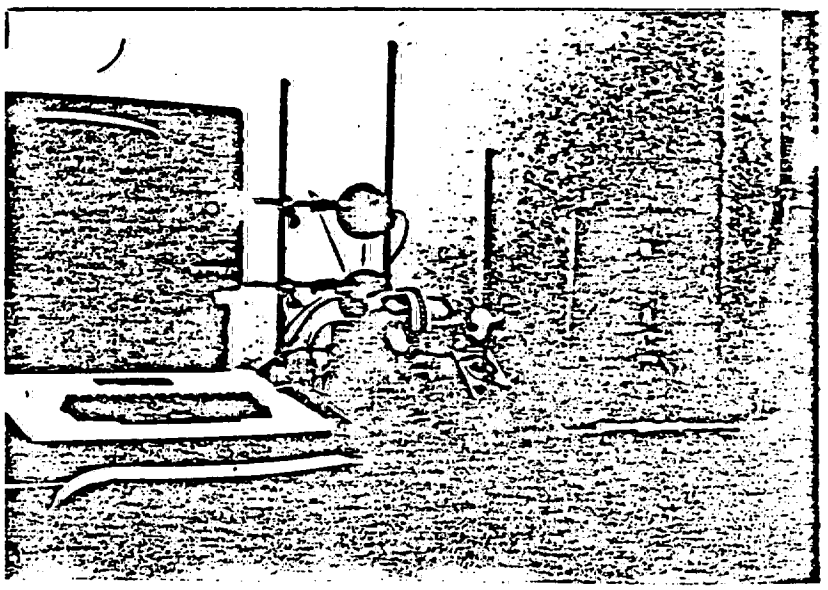


3a. Filtrona ventilation sleeve with cigarette



3b. Puff profile analyzer (PPA) with ventilation sleeve and Kamm holder in place



c. Complete ventilation study apparatus

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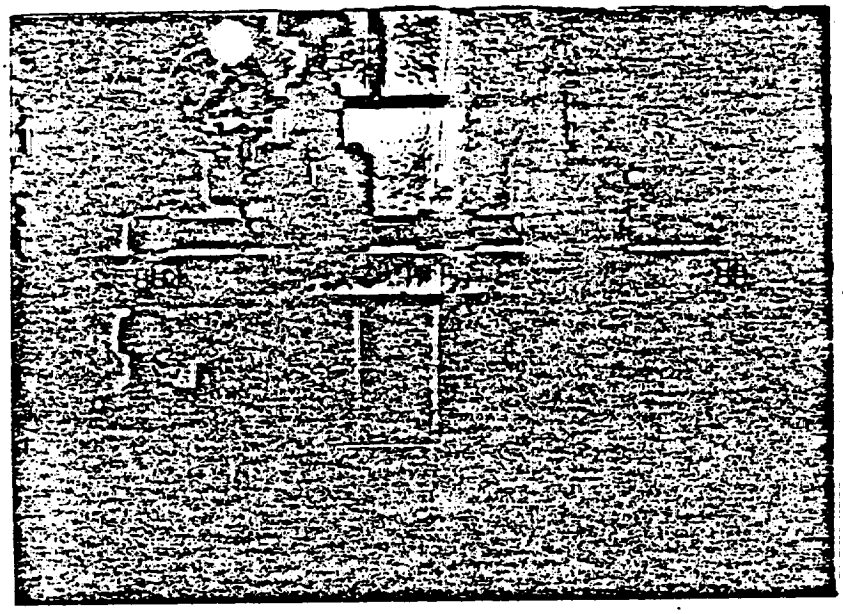
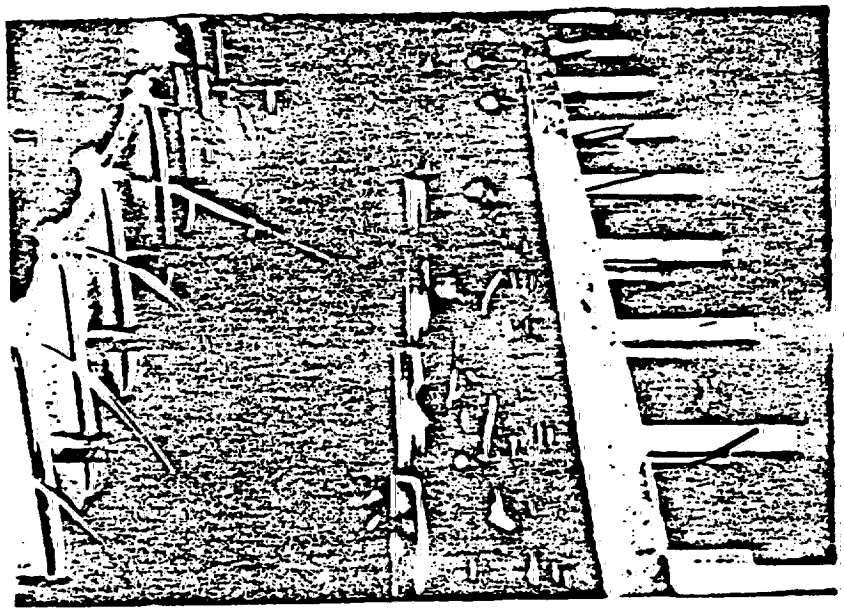
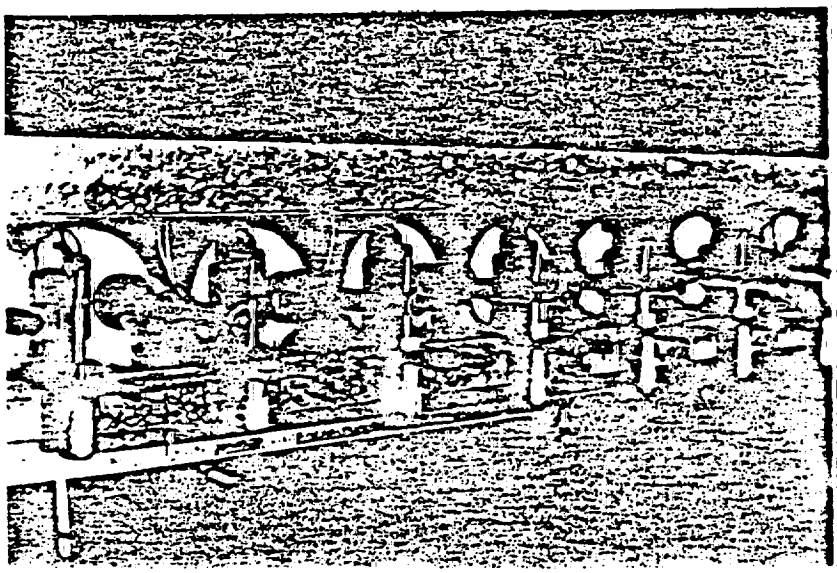


4a. Pressure/vacuum manifold serving two Phipps & Bird smoke machines



4b. Side view of Phipps & Bird smoke machine with Kamm holders in place



4c. Front view of Phipps & Bird smoke machine with Kamm holders in place

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APPENDIX E

STANDARD ANALYTICAL METHODS FOR TAR, NICOTINE, AND CARBON MONOXIDE

2023100167

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BROWN & WILLIAMSON TOBACCO CORPORATION

Research Department

Standard Method of Analysis

Method No.: SM-100 Date Issued: July 22, 1982

PROCEDURE FOR THE SIMULTANEOUS DETERMINATION OF NICOTINE AND WATER IN CAMBRIDGE PADS AND NICOTINE IN CIGARETTE FILTER TIPS

Mr. M. S. Frank

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BROWN & WILLIAMSON TOBACCO CORPORATION

Research Department

Standard Method of Analysis

Method No.: SM-100 Date Issued: July 22, 1982

Method Class:

Title: PROCEDURE FOR THE SIMULTANEOUS DETERMINATION OF NICOTINE AND WATER IN CAMBRIDGE PADS AND NICOTINE IN CIGARETTE FILTER TIPS

Authors: Mr. M. S. Frank M. S. Frank

Dr. O. C. Lin O. C. Lin

Mr. D. C. Hilton D. C. Hilton

Summary: Cambridge pads or filter tips are extracted with isopropyl alcohol containing two internal standards. Nicotine and water are separated and measured from a single injection using gas chromatography. The injection is split onto separate columns and detectors.

Sample Size: This method is used to measure water and nicotine in samples containing particulate smoke from ten cigarettes or the nicotine in ten cigarette filter tips.

Range and/or Sensitivity: Water can be determined in samples containing from 0.2 to 4.0 mg/cig. (0.1 to 2.0 mg/mL).

Nicotine can be measured routinely from 0.1 to 1.5 mg/cig. (0.05 to 0.75 mg/mL). Higher concentrations can be measured with dilution. (See Appendix III.) Nicotine deliveries as low as 0.001 mg/cig. (0.5 ug/mL) can be measured by reducing the amount of internal standard and increasing sensitivity of the nitrogen - phosphorous detector. (See Appendix III.)

2023100169

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Precision: Water - A precision study was carried out for five weeks. A 1.0 mg/cig. standard solution gave a standard deviation of 0.09 mg/cig. This was equal to a relative standard deviation of 9%. For the cigarette samples, the relative standard deviation ranged from 10% to 60%.

Nicotine - A comparative study between this method and the Auto-Analyzer was carried out along with the water precision study. The precision of this method was equal to that of the AutoAnalyzer. The standard deviation for the 1.0 mg/cig. standard solution was 0.05 mg/cig. The percent relative standard deviation was 5%. For cigarette pads and filters, the relative standard deviation was about 15% or less in most brands.

Analysis Time - Setup: (man-hours) - 6

- Take Down: (man-hours) - 4

- Variable: (man-hours/sample) - 0.1

Approved for Issue: J.H. Jackson Date: July 23, 1982

F. Tall Date: July 23, 1982

2023100170

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1. Principle of Method

Nicotine and water are determined simultaneously using gas chromatography. Cambridge pads and cigarette filters containing whole smoke are extracted with isopropanol which contains two internal standards. The sample is split in a special injection port onto two packed columns. Water, using methanol as the internal standard, is determined using a thermal conductivity detector. Nicotine, with quinoline as the internal standard, is measured using a nitrogen/phosphorous specific detector.

2. Range and Sample Size

2.1 This method can be used to measure water and nicotine in whole smoke from ten cigarettes or nicotine in ten cigarette filters.

2.2 Nicotine can be measured routinely from 0.1 to 1.5 mg/cig. Higher concentrations can be measured with dilution. Nicotine levels as low as 0.001 mg/cig. can be measured with adjustments in the internal standard concentration. (See Appendix III.) The limit of detection is 0.0005 mg/cig. (0.25 μg/mL).

2.3 Water can be measured from 0.2 to 4.0 mg/cig. (0.1 to 2.0 mg/mL).

3. Safety Precautions

Normal safety precautions are employed.

Nicotine is a poison and should be handled with care using rubber gloves in a fume hood.

4. Interferences and Correlative Measurements

None were investigated.

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5. Precision and Bias

The method for the simultaneous determination of nicotine and water was highly accurate. This was shown by the small bias of -0.008 mg/cig. observed in a 1.0 mg/cig. water standard solution and the +0.005 mg/cig. bias observed in a 1.0 mg/cig. nicotine standard solution. The percent relative standard deviations (RSD) for the 1.0 mg/cig. water standard and the 1.0 mg/cig. nicotine standard were respectively equal to 9% and 5%.

5.1 Experimental Determination of Precision and Bias

5.1.1 Using the procedure described in this methodology, a precision study for nicotine and water was carried out. At the same time a comparative study (nicotine only) between this method and the AutoAnalyzer method was carried out. For precision estimations, samples from 1.0 mg/cig. standard solutions were analyzed for about five weeks. For the comparison between this method and the AutoAnalyzer, samples of the 1.0 mg/cig. standard solution and samples of cigarette pads and filters were analyzed by both methods for five weeks.

5.1.2 Standard solution samples of nicotine and water were analyzed between cigarette samples. The same cigarette samples were analyzed by both methods.

5.1.3 BCR-2 (BARCLAY) and KSL-3 (KOOL) were used as cigarette control samples. Several samples of each were analyzed daily.

5.1.4 The method was calibrated as outlined in Section 8. The calibration graphs for nicotine and water were linear over the range of 0.1 to 1.5 mg/cig. for nicotine and 0.25 to 4.0 mg/cig. for water.

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5.2 Method Bias

5.2.1 The nicotine and water bias of this method was assessed using data from 1.0 mg/cig. standard solutions which were analyzed between cigarette samples.

5.2.2 The observed mean value for this 1.0 mg/cig. nicotine standard was 1.006 mg/cig.; therefore, the bias was +0.006 mg/cig. However, statistical testing showed that the bias was not significantly different from zero.

5.2.3 The observed mean value for the 1.0 mg/cig. water standard solution was 0.992 mg/cig.; hence, the bias was -0.008 mg/cig. Again, the statistical testing showed that the bias was not significantly different from zero.

5.2.4 For pad nicotine results, the differences between this method and the AutoAnalyzer were small. On average, this method gave results which were 4% lower than those found by the AutoAnalyzer. For filter nicotine results, the differences between these methods depended on the cigarette brand tested. The differences for a number of brands are shown in the table on page 7 and 8. A more complete listing of differences for the brands is given in Appendix IV.

5.3 Method Precision

5.3.1 The estimated standard deviation for the 1.0 nicotine standard solution was 0.05 mg/cig. The relative standard deviation was 5%. For cigarette pad and filter samples, the standard deviation at the 0.2 mg/cig. nicotine level was about 0.08 mg/cig. and at the 1.0 mg/cig. level was about 0.12 mg/cig. The relative standard deviations for most of the cigarette brands were less than 15% in pad and filter nicotine analyses.

Similar magnitudes in standard deviations were observed in the AutoAnalyzer method which analyzed the same cigarette samples.

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5.2 Method Bias

5.2.1 The nicotine and water bias of this method was assessed using data from 1.0 mg/cig. standard solutions which were analyzed between cigarette samples.

5.2.2 The observed mean value for this 1.0 mg/cig. nicotine standard was 1.006 mg/cig.; therefore, the bias was +0.006 mg/cig. However, statistical testing showed that the bias was not significantly different from zero.

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Similar magnitudes in standard deviations were observed in the AutoAnalyzer method which analyzed the same cigarette samples.

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BROWN AND WILLIAMSON TOBACCO CORPORATION

DIFFERENCE IN NICOTINE RESULTS BETWEEN THE AUTOANALYZER AND GAS CHROMATOGRAPHIC METHODS AND THE PRECISION OF EACH METHOD

11

BRAND DESCRIPTION	PAD ANALYSIS NUMBER OF RESULTS	PAD ANALYSIS MEAN RESULT	PAD ANALYSIS STANDARD DEVIATION	FILTER ANALYSIS NUMBER OF RESULTS	FILTER ANALYSIS MEAN RESULT	FILTER ANALYSIS STANDARD DEVIATION	WRE NUMBER OF RESULTS	WRE MEAN RESULT	WRE STANDARD DEVIATION
BARCLAY BOX, PETERSBURG									
BY AA	242	0.392	0.061	167	0.465	0.092	161	73.04	3.68
BY GC	242	0.203	0.077	167	0.531	0.129	161	74.81	4.68
MEAN DIFFERENCE	242	-0.012*	0.031	167	-0.066*	0.061	161	-1.76	2.70
BARCLAY MENTHOL 100, LOUISVILLE									
BY AA	115	0.322	0.083	97	0.339	0.043	97	52.44	4.44
BY GC	115	0.325	0.089	97	0.356	0.049	97	53.65	5.33
MEAN DIFFERENCE	115	-0.003	0.028	97	-0.016*	0.033	97	-1.21	2.42
BARCLAY MENTHOL 100, PETERSBURG									
BY AA	103	0.373	0.069	34	0.412	0.046	33	51.75	4.30
BY GC	103	0.417	0.077	34	0.454	0.050	33	51.32	4.57
MEAN DIFFERENCE	103	-0.044*	0.030	34	-0.042*	0.028	33	0.43	2.14
BARCLAY MENTHOL, LOUISVILLE									
BY AA	83	0.132	0.074	72	0.288	0.044	70	69.87	4.79
BY GC	83	0.114	0.070	72	0.312	0.046	70	74.38	4.45
MEAN DIFFERENCE	83	0.017*	0.016	72	-0.024*	0.026	70	-4.51	2.45
BARCLAY MENTHOL, PETERSBURG									
BY AA	94	0.187	0.046	39	0.384	0.066	38	69.04	3.80
BY GC	94	0.180	0.050	39	0.386	0.052	38	70.28	3.51
MEAN DIFFERENCE	94	0.007*	0.028	39	-0.002	0.040	38	-1.25	3.76
BARCLAY 100, LOUISVILLE									
BY AA	179	0.344	0.072	132	0.355	0.041	127	51.03	3.33
BY GC	179	0.335	0.043	132	0.358	0.043	127	52.31	3.93
MEAN DIFFERENCE	179	0.009*	0.053	132	-0.003	0.039	127	-1.27	2.77
BARCLAY, LOUISVILLE									
BY AA	122	0.161	0.055	89	0.410	0.083	85	72.24	4.27
BY GC	122	0.141	0.053	89	0.459	0.084	85	76.84	4.37
MEAN DIFFERENCE	122	0.020*	0.026	89	-0.049*	0.042	85	-4.60	2.61
BARCLAY, PETERSBURG									
BY AA	231	0.175	0.052	140	0.426	0.074	133	72.61	4.20
BY GC	231	0.177	0.063	140	0.480	0.101	133	75.20	4.61
MEAN DIFFERENCE	231	-0.002	0.029	140	-0.055*	0.053	133	-2.59	2.80
BCP - 2									
BY AA	369	0.253	0.077	298	0.591	0.073	280	70.87	4.32
BY GC	369	0.245	0.065	298	0.643	0.081	280	73.1[illegible]	4.31
MEAN DIFFERENCE	369	0.008*	0.043	298	-0.052*	0.065	280	-2.28	3.09
BELAIRE 100, PETERSBURG									
BY AA	39	0.840	0.127	33	0.575	0.045	33	40.79	3.29
BY GC	39	0.825	0.142	33	0.510	0.042	33	38.50	3.51
MEAN DIFFERENCE	39	0.015	0.045	33	0.064*	0.031	33	2.29	1.68
KENT GOLDEN LIGHTS KS, PETERSBURG									
BY AA	41	0.555	0.084	34	0.502	0.048	34	47.55	2.51
BY GC	41	0.540	0.096	34	0.483	0.049	34	47.76	3.04
MEAN DIFFERENCE	41	0.015*	0.037	34	0.019*	0.026	34	-0.18	1.42
KOOL BOX 4LET, PETERSBURG									
BY AA	99	1.204	0.166	72	0.737	0.092	71	39.03	5.77
BY GC	99	1.155	0.190	72	0.606	0.076	71	35.82	6.49
MEAN DIFFERENCE	99	0.054*	0.054	72	0.131*	0.069	71	3.21	2.57
KOOL KING BXLET, MACON									
BY AA	80	1.251	0.202	61	0.675	0.092	61	37.99	4.54
BY GC	80	1.109	0.196	61	0.536	0.074	61	33.69	5.20
MEAN DIFFERENCE	80	0.042*	0.047	61	0.138*	0.050	61	4.30	1.90

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DIFFERENCE IN NICOTINE RESULTS BETWEEN THE AUTOANALYZER AND GAS CHROMATOGRAPHIC METHODS AND THE PRECISION OF EACH METHOD

BW DESCRIPTION	PAD ANALYSIS NUMBER OF RESULTS	PAD ANALYSIS MEAN RESULT	PAD ANALYSIS STANDARD DEVIATION	FILTER ANALYSIS NUMBER OF RESULTS	FILTER ANALYSIS MEAN RESULT	FILTER ANALYSIS STANDARD DEVIATION	WRE NUMBER OF RESULTS	WRE MEAN RESULT	WRE STANDARD DEVIATION
KOOL LIGHT 100 95M1, MACON									
BY AA	72	0.895	0.088	60	0.716	0.047	60	44.37	2.17
BY GC	72	0.921	0.090	60	0.666	0.062	60	41.87	2.03
MEAN DIFFERENCE	72	-0.026*	0.083	60	0.050*	0.054	60	2.50	2.26
KOOL LIGHT 100, PETERSBURG									
BY AA	96	0.812	0.123	77	0.669	0.074	74	45.30	3.64
BY GC	96	0.796	0.127	77	0.638	0.067	74	44.88	3.39
MEAN DIFFERENCE	96	0.015*	0.046	77	0.031*	0.048	74	0.42	2.34
KOOL LIGHT, PETERSBURG									
BY AA	31	0.723	0.083						
BY GC	31	0.711	0.074						
MEAN DIFFERENCE	31	0.012	0.038						
KOOL MILD 100, LOUISVILLE									
BY AA	63	0.904	0.100	43	0.630	0.076	40	41.30	2.75
BY GC	63	0.917	0.130	43	0.547	0.056	40	38.72	3.10
MEAN DIFFERENCE	63	-0.013	0.085	43	0.083*	0.043	40	2.59	1.39
KOOL MILD, MACON									
BY AA	38	0.831	0.133	34	0.768	0.085			
BY GC	38	0.812	0.120	34	0.672	0.086			
MEAN DIFFERENCE	38	0.018	0.070	34	0.096*	0.063			
KOOL ULTRA 100, LOUISVILLE									
BY AA	74	0.491	0.071	47	0.443	0.048	38	46.24	3.09
BY GC	74	0.539	0.089	47	0.463	0.061	38	45.38	3.57
MEAN DIFFERENCE	74	-0.048*	0.062	47	-0.020*	0.041	38	0.87	1.90
KOOL ULTRA, LOUISVILLE									
BY AA	68	0.208	0.046	35	0.343	0.049	30	62.93	2.89
BY GC	68	0.215	0.069	35	0.374	0.061	30	65.08	4.28
MEAN DIFFERENCE	68	-0.007	0.034	35	-0.031*	0.037	30	-2.16	2.56
KSL - 3									
BY AA	395	0.546	0.075	283	0.644	0.057	272	53.84	3.08
BY GC	395	0.542	0.083	283	0.579	0.071	272	51.59	4.49
MEAN DIFFERENCE	395	-0.002	0.066	283	0.065*	0.063	272	2.25	3.76
VICEROY RICH LIGHTS 100, PETERSBURG									
BY AA	30	0.801	0.155	30	0.755	0.110	30	48.75	4.48
BY GC	30	0.787	0.144	30	0.698	0.110	30	47.14	4.63
MEAN DIFFERENCE	30	0.014	0.055	30	0.057*	0.045	30	1.60	1.73
VICEROY RICH LIGHTS, JAPAN									
BY AA	36	1.012	0.025						
BY GC	36	0.974	0.093						
MEAN DIFFERENCE	36	0.036*	0.056						

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5.3.2 The estimated standard deviation for the 1.0 mg/cig. water standard was 0.09 mg/cig. The relative standard deviation was 9%. For cigarette samples, the standard deviations ranged from 0.1 mg/cig. to 0.7 mg/cig. as the water levels ranged from 0.2 mg/cig. to 2.3 mg/cig.

5.3.3 For BCR-2 cigarette samples, the estimated within-day standard deviations were 0.06 and 0.08 mg/cig. respectively, for pad and filter. For KSL-3 samples, the estimated within-day standard deviations were 0.08 and 0.07 mg/cig. respectively for pad and filter.

For water samples from the BCR-2 and KSL-3, the estimated within-day standard deviations were 0.19 and 0.18 mg/cig. for BCR-2 and KSL-3 respectively.

6. Apparatus

6.1 Hewlett-Packard 5730 Gas Chromatograph or equivalent, equipped with a nitrogen/phosphorous specific detector and a thermal conductivity detector.

6.2 Hewlett-Packard 7672A auto sampler, or equivalent, equipped to hold 99 samples.

6.3 Column for nicotine - 4' x 1/8" stainless steel packed with 10% Carbowax 20M + 2% KOH on 80/100 mesh Chromosorb W AW. Use Graphlok ferrules. Available from Alltech, Inc. (preconditioned).

6.4 Column for water - 8' x 1/8" copper packed with 50/80 mesh Porapak Q. Use Graphlok ferrules. Available from Alltech, Inc. (preconditioned).

6.5 Modified injection port liner for "A" injector. This was fabricated in the B&W Machine Shop. (See Figure 1.)

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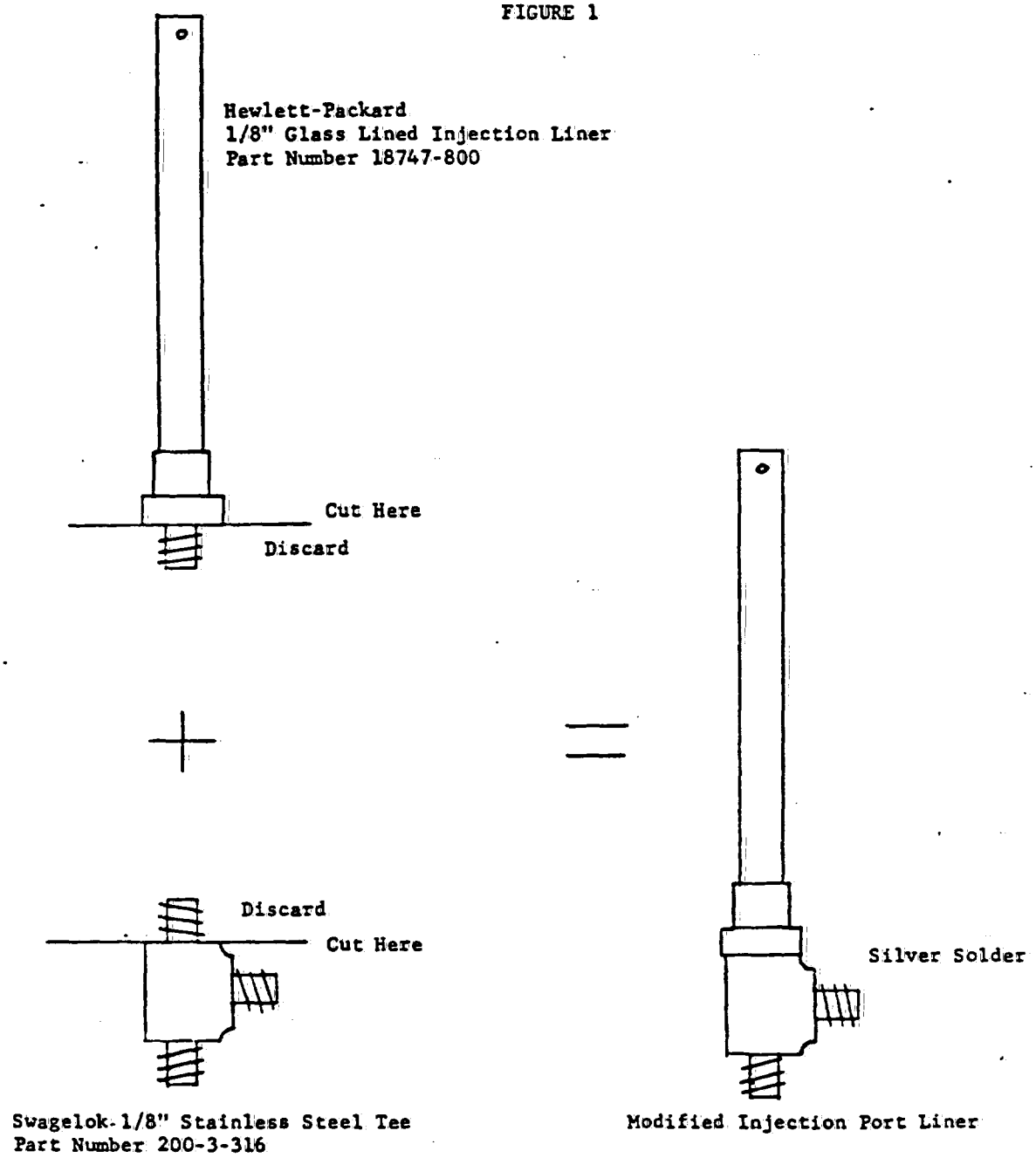
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

FIGURE 1



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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

6.6 Column ferrules - 1/8" Graphloks (one piece) from Supelco, Inc., Catalog #2-2603.

6.7 Injection port liner ferrules - 1/4" Graphloks (one piece) from Supelco, Inc. Catalog #2-2604.

6.8 "Up and Down" sample shaker - fabricated in B&W Machine Shop from a Frigidare washing machine mechanism.

6.9 Extraction vials with caps - 29 mm O.D. x 65 mm long, 30 mL capacity from Preiser, Inc., Catalog #10-5032-25.

6.10 Auto sampler sample vials - 1 mL capacity by Wheaton from Preiser, Inc., Catalog #10-4788-12.

6.11 Auto sampler sample vial caps - 11 mm O.D. from Preiser, Inc., Catalog #10-4805-29.

6.12 Auto sampler sample vial cap crimper by Wheaton from Preiser, Inc., Catalog #10-4814-13.

6.13 Labindustries Micro Pipettors are used to make standard solutions.

Catalog No.	Volume (µl)
MP-5H	5
MP-10H	10
MP-20H	20
MP-30H	30
MP-40H (Special Order)	40
MP-20H	20
MP-100H	100
MP-200H	200

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620 Hearst Avenue
Berkeley, CA 94710

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7. Reagents and Standards

7.1 The following reagents are required:

(a) Nicotine (distilled) GLC assay 98%, Eastman Catalog #1242.

(b) Quinoline - ACS Reagent Grade - GLC assay 99%, Eastman Catalog #218 or Alfa Products, Catalog #11927.

(c) Methanol - ACS Reagent Grade - GLC assay 99%, Eastman Catalog #13032.

(d) Isopropanol - ASC Reagent Grade - Spectro Grade, Water - 0.2% max.

(e) Water - Reagent Grade from Millipore Reverse Osmosis unit.

7.2 Extracting Solution

Unopened five-gallon cans of isopropanol are to be used. Under normal smoking conditions, i.e., eight machine loads/day, this will last two working days. The unused extracting solution should be discarded at the end of the second working day.

7.2.1 Pipette 25 mL of quinoline and 70 mL of methanol into the can of isopropanol after opening. Stopper and mix well.

Label: Internal Standard Added
Date -
Technician -

7.2.2 <u>ISOPROPANOL PICKS UP WATER EXTREMELY FAST!</u>
<u>KEEP THE ISOPROPANOL STOPPERED AT ALL TIMES</u>.

7.2.3 Methanol is the water internal standard and quinoline is the nicotine internal standard.

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7.3 Combined Nicotine/Water Standards

These standards must be made in glassware, extraction vials, transfer syringes, etc., that have been oven dried at 125°C for at least four hours and cooled in a dessicator over Dryrite. The standards must be made, transfered, and capped in a "dry-box" under anhydrous conditions.

Nicotine used to make the standards must be redistilled under reduced pressure in a nitrogen atmosphere. The nicotine must be colorless. Nicotine stored in the dark at -10°C to -20°C under nitrogen will remain colorless for about six months. See Appendix I for nicotine distillation procedure.

Water used to make standards must be fresh distilled water.

7.3.1 Nicotine Stock Solution

Weigh exactly 500 mg (0.500 g) of redistilled nicotine into a 10 mL volumetric flask and dilute to volume with isopropanol that contains no internal standard. After thorough mixing, transfer the solution to a glass stoppered 10 mL Erlenmeyer flask. Concentration = 50 mg/mL or 0.5 mg/10 µL.

Label: Nicotine Stock Solution
0.5 mg/10 µL
Date _
Technician Name -

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7.3.2 Nicotine/Water Working Standards

Place two whole Cambridge pads and two quarter pads into each of seven extraction vials. Add water and nicotine stock solution as shown in Table 1 to these vials using Labindustries micropipettors. The zero water addition level is the solvent blank. After the correct amount of water and nicotine stock solution have been added to each vial, 20 mL of extracting solution is added by pipette or autopipette and the vials shaken on an "up and down" shaker for 15 minutes.

Label: Nicotine/Water Working Standard
Concentration -
Date -
Technician -

7.3.3 Return extracted standards to the "dry-box" and carefully transfer aliquots to the sample vials. Cap the sample vials. Use a clean, dry syringe to transfer each standard.

7.3.4 All standards except the 0.25 mg/cig. nicotine are made by pipetting 20 mL of extracting solution to the stock solutions. The 0.25 mg/cig. nicotine standard is made by pipetting 40 mL of extracting solution to the stock solutions.

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TABLE 1

COMBINED NICOTINE/WATER STANDARDS

Standards

Micropipettor Volume (µL)			Concentration (mg/cig.)*	
Nicotine Stock	Distilled Water		Nicotine	Water
20	0	Cal. Std.**	0.1	Blank
300	30	Cal. Std.**	1.5	3.0
200	10	Control	1.0	1.0
100	5		0.5	0.5
0	20		0	2.0
0	40		0	4.0
0	5	(40 mL Ex. Sol)	0	0.25

*These concentrations are based on the assumption that five cigarettes are smoked per pad and two pads are extracted with 20 mL of extracting solution.

**Calibration standards for PAMILA computer system.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

7.4 For best results and ease of sample handling, make a set of standards for each GC to be standardized.

7.5 Approximately three auto sampler vials (1.5 mL capacity) can be filled from a working standard extract.

7.6 Each standard vial can be used for only one injection because water is picked up through the needle puncture.

7.7 The accuracy of standards made using the Labindustries "push button" pipettors should be checked at regular intervals against standards made using Class A volumetric pipettes.

8. Standardization or Calibration

8.1 Set up the instrumentation as described in Section 9.2

8.2 Make five replicate injections of a smoke sample to condition the column system.

8.3 Using a clean, dry 10 µL syringe, make duplicate 2 µL injections of the standards in order.

8.4 Compounds elute from the water column as follows:

Compound	Time (min.)
Air	0.20
Water	0.30
Methanol (Internal Standard)	0.40
Isopropanol (Solvent)	1.00

See Figure 2 for a typical chromatogram of a standard (water).

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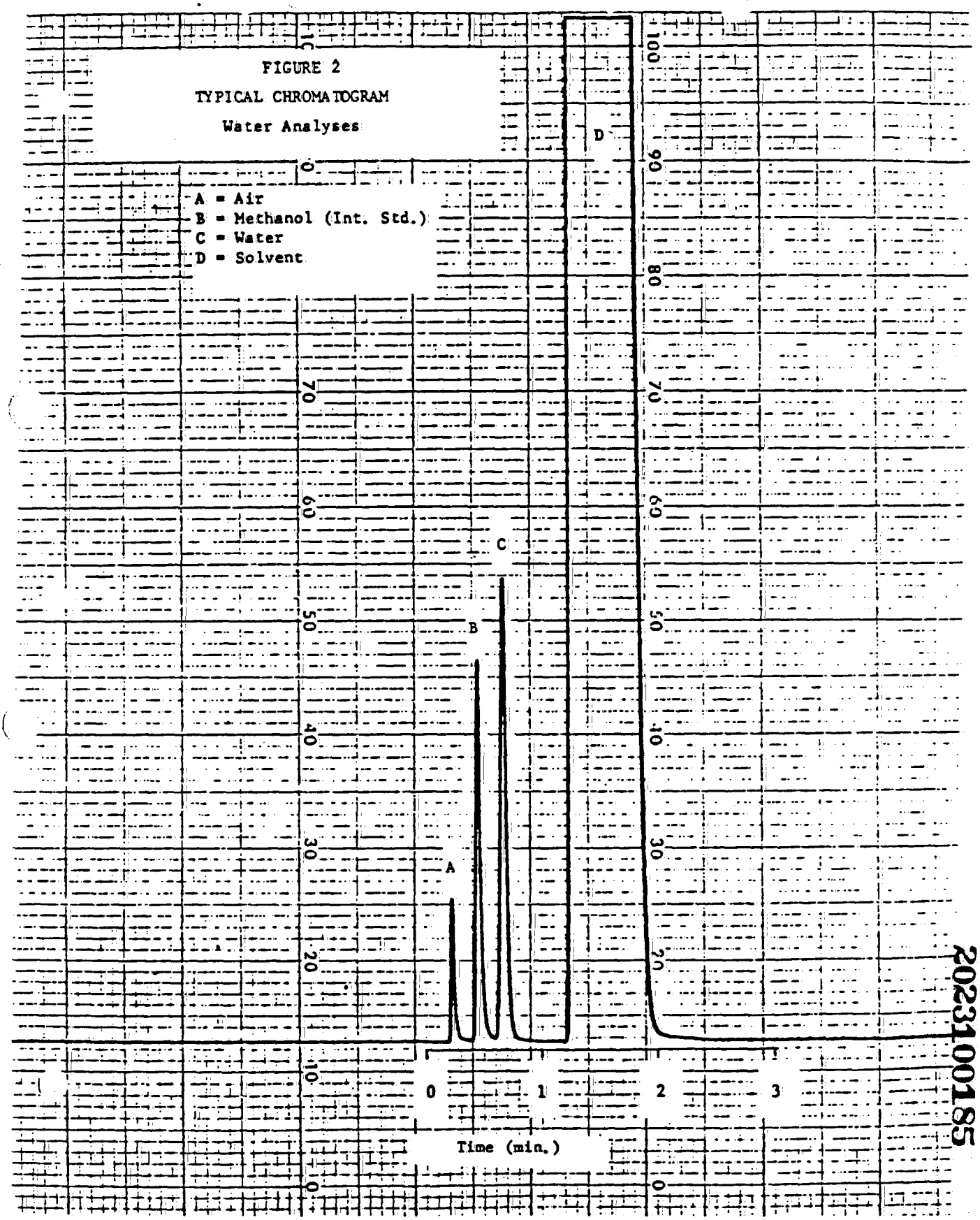
FIGURE 2

TYPICAL CHROMATOGRAM

Water Analyses



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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

8.5 Compounds elute from the nicotine column as follows:

Compound	Time (min.)
Isopropanol (Solvent)	0.20
Nicotine	1.40
Quinoline (Internal Standard)	2.00

See Figure 3 for a typical chromatogram of a standard (nicotine).

8.6 This methodology assumes that peak areas will be determined by an integrator or computer. However, peak height measurements can be used for manual calculations.

8.7 Determine the peak area ratios for both the nicotine and the water standards as follows:

$$\frac{\text{Peak area (water or nicotine)}}{\text{Peak area internal standard}} = \text{Peak Area Ratio}$$

8.8 Using the method of least squares, carry out linear regression analysis and determine the slope, Y-intercept, and correlation coefficient.

8.9 The correlation coefficient must be greater than 0.98 or the standardization must be repeated.

8.10 Substitute the slope and Y-intercept in the following linear regression equation:

$$X = \frac{Y - (\text{Y-intercept})}{\text{Slope}}$$

X = amount of water or nicotine in mg/cig.

Y = peak area ratio of water or nicotine

8.11 Steps 8.8 through 8.11 should be ignored if the integrator or computer can perform a multi-point calibration.

8.12 If the gas chromatograph is interfaced with the PAMILA computer system, inject the standards as outlined in Section 12.7.

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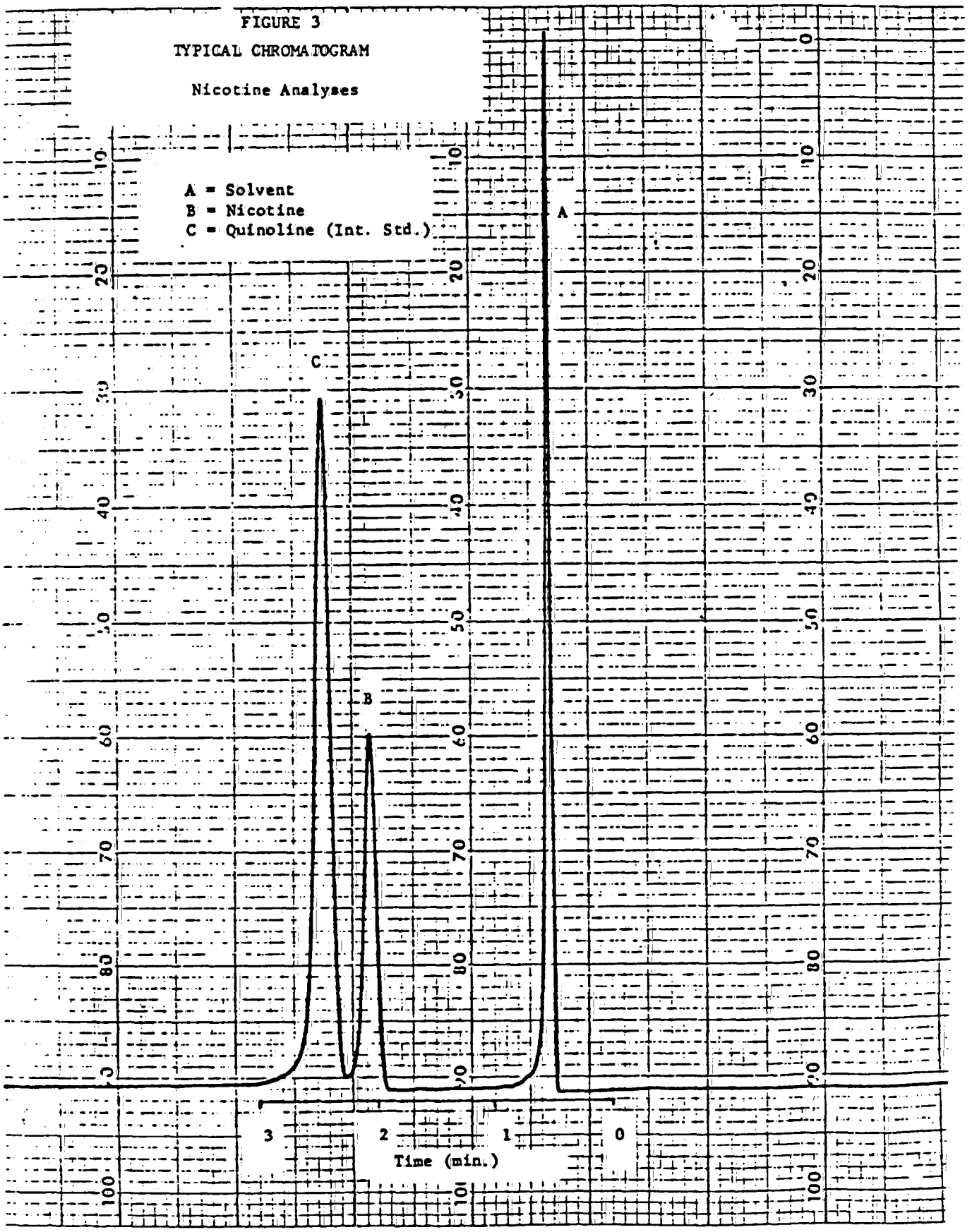
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

FIGURE 3

TYPICAL CHROMATOGRAM

Nicotine Analyses



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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

9. Procedure

9.1 Gas Chromatograph Conditions

Column Oven Temperature - 200°C

Injection Size - 2 µl

Thermal Conductivity Detector:

Temperature - 250°C

Sensitivity - 5 (Current = 150 milliamps)

Attenuation - X4

Carrier Gas Flow - 2 mL/min.

Carrier Gas - Helium

Polarity - 'A'

Offset - 'None'

NOTE: Reference and carrier flow should be equal.

Compound Detected - Water

Nitrogen/Phosphorous Detector:

Temperature - 300°C

Air Flow - 50 mL/min.

Hydrogen Flow - 3.2 mL/min.

Collector Voltage - 18-20

Electrometer Range - X100

Attenuation - X1024

Carrier Gas Flow - 15 mL/min.

Carrier Gas - Helium

Compound Detected - Nicotine

9.2 Automatic Sampler Conditions

Operating Mode - Auto

Stop Integrate - 0

Analysis Cycle - 2 min.

Injections per sample - 1

Wash Cycle - Minimum

Syringe Stroke - Stop 1

(Inject - 2 µl)

Total Analysis Time - 3 min.

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9.3 Column System Installation

9.3.1 Install a modified H-P 1/8" injection port liner (H-P Part No. 18744A) in the "A" injector. The modification was carried out in the B&W Machine Shop. (See Figure 1.)

9.3.2 Attach the nicotine column to the side outlet of the injector using a 1/8" Graphlok ferrule.

9.3.3 Attach a 1/8" to 1/16" Swagelok reducing union to the outlet of the nicotine column.

9.3.4 Attach a 2' x 0.009" I.D. x 1/16" O.D. stainless steel flow restrictor to the outlet of the nicotine column. This tubing is available from most high-pressure liquid chromatography supply houses.

9.3.5 Connect the outlet of the flow restrictor to the "B" nitrogen/phosphorous detector (N/PD.) using a Supelco reducing ferrule 1/8" to 1/16".

9.3.6 Attach the water column to the bottom outlet of the injector using a 1/8" Graphlok ferrule.

9.3.7 Attach the outlet of the water column to the "A" inlet of the thermal conductivity detector (TCD).

9.3.8 Attach a reference gas line to the "B" side of the TCD. Run a 1/8" copper line from the "B" injector to the TCD. Be sure to first install a H-P injection port liner (H-P Part No. 18744A) in the "B" injector. No injections are made into "B" injector!

9.3.9 This allows the "B" flow controller to be used to adjust the reference gas flow to the TCD.

9.3.10 Install a plug in the inlet of the unused "A" N/PD.

9.3.11 Adjust the carrier gas flow through the water column to 25 mL/min. using the "A" flow controller.

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9.3.12 Carefully leak check all connections using a 1:1 solution of methanol:water. DO NOT USE "SNOOP" OR ANY SOAP SOLUTION because they may contain phosphates which could contaminate the N/P detector. If leaks are found, repair and readjust carrier flow.

9.3.13 Allow carrier gas to flow through the column system for 15 minutes before heating to 210°C. Allow the column system to equilibrate ten minutes before making final flow adjustments.

9.3.14 Check the flow through the water column and adjust to 25 mL/min. if necessary.

9.3.15 Adjust TCD reference gas flow to 25 mL/min. using "B" flow controller.

9.3.16 Check carrier flow through the nicotine column. The flow should be 12 mL/min. ±2 mL/min. If the flow falls outside these limits, the length of the flow restrictor must be changed. A shorter restrictor increases the flow and a longer restrictor reduces flow. After the restrictor is changed, the flow through the water column must be adjusted.

9.3.17 Turn-on the thermal conductivity detector. See Section 9.5

9.3.18 Turn-on the nitrogen/phosphorous detector. See Section 9.6.

9.3.19 After the detectors have stabilized, inject 2-3 µL of a smoke sample that contains both internal standards into the "A" injector.

9.3.20 A typical chromatogram should take about three minutes. See Figures 2 and 3.

9.3.21 The temperature of the column system can be adjusted to improve resolution. Increasing the column temperature generally causes faster elution of the compounds.

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9.3.22 The carrier gas flow can also be adjusted to improve resolution. Increasing the flow generally causes faster elution of the compounds.

9.3.23 If no response is obtained from the detectors or if the chromatograms do not resemble those in Figures 2 and 3, see Section 9.4 - Troubleshooting.

9.4 Troubleshooting

9.4.1 If a sample is injected and no response is observed from either detector; check for a leaking septum, large column leak at the injector, or a plugged injector. Make sure that the electronic equipment is working properly.

9.4.2 If no response is observed on the TC detector; check for a plugged column, leak at the detector inlet, or detector malfunction.

9.4.3 If no response is observed for the N/P detector; check for a plugged column, plugged restrictor, leak at the detector inlet, collector "BEAD" failure, or other detector malfunction.

9.4.4 Changes in peak retention time usually indicate changes in flow, temperature, or column failure.

9.4.5 "Noise" in the chromatogram usually indicates a gas leak, impure gases, or dirty detector.

9.4.6 Loss of sensitivity with the TC detector usually indicates a leak or dirty filaments (usually accompanied by electronic noise).

9.4.7 Loss of sensitivity for the N/P detector indicates improper collector height, incorrect H_2 or air flow, impure gases, or low collector voltage. Some loss of sensitivity is normal as the collector ages.

9.5 Thermal Conductivity Detector Start-Up

9.5.1 Set the detector temperature to 250°C and allow the temperature to stabilize. This takes two to five hours.

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9.5.2 Adjust the flow of the reference side carrier gas using the "B" flow controller to match the flow of the water column.

9.5.3 Set the sensitivity knob at five, the attenuation to four, the offset to none, and the polarity switch to "A."

9.5.4 Inject 2 to 3 µL of the 4 mg water standard. The chromatogram should resemble that shown in Figure 2. A complete chromatogram should take two to three minutes.

9.6 Nitrogen/Phosphorous Detector Start-Up

9.6.1 Set the detector temperature to 300°C and allow temperature to stabilize. This takes one to two hours.

9.6.2 Carrier gas must be flowing through the detector before the collector voltage is turned on or the collector will quickly burn out.

9.6.3 Set hydrogen range valve lever in the down position - 0 to 7 mL/min. (See Figure 4.)

9.6.4 Set hydrogen flow for detector "B" to 3.2 mL/min.

9.6.5 Set air flow for detector "B" to 50 mL/min.

9.6.6 Set meter select switch to "B" detector.

9.6.7 Rotate the voltage knob for detector "B" counterclockwise to stop.

9.6.8 Set the electrometer range to 1.

9.6.9 Set attenuation to X8.

9.6.10 Turn on voltage to the detector "B." The meter will read about ten volts.

9.6.11 Raise voltage until a 10% rise in the baseline is observed on the recorder.

9.6.12 Hold this baseline for one hour, adjusting voltage as necessary to maintain this offset.

9.6.13 After an hour, slowly raise voltage over a period of three hours to 19-20 volts.

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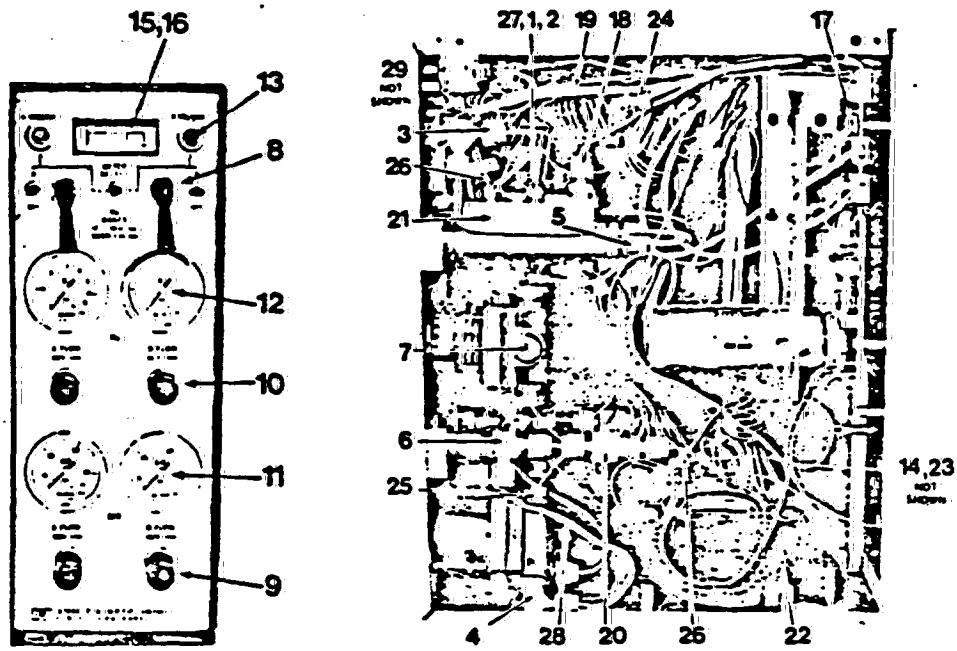
FIGURE 4

N-P CONTROL MODULE



Item	Description	Part Number	Qty
1	Front Ferrule, 1/8T	0100-0032	6
2	Back Ferrule, 1/8T	0100-0036	6
3	Tubing Nut, 1/8T	0100-0058	2
4	Male Elbow, 90°, 1/8T, 1/8 PM	0100-0065	2
5	Male Connector, 1/8T, 1/8 PM	0100-0110	6
6	Female Branch Tee, 1/8T, 1/8F, 1/8T	0100-0713	2
7	Pipe Plug, 1/8M NPT, stainless steel	0100-0887	4
8	Toggle Valve	0101-0296	2
9	Pressure Regulator, Air	0101-0352	2
10	Pressure Regulator, H_2	0101-0358	2
11	Pressure Gauge, Air	0101-0360	2
12	Pressure Gauge, H_2	0101-0361	2
13	Round Knob	0370-1091	2
14	Nut, 5/16-20, brass	0590-0385	2
15	Panel Meter, 0-30 VDC	1120-0619	1
16	Meter Support	18789-00120	1

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9.6.14 Set the electrometer range to 100.

9.6.15 Set attenuation to X1024.

9.6.16 Using the electrometer coarse zero, set the baseline at 10%.

9.6.17 Inject 2 µL of the highest nicotine standard. The nicotine peak should be 15 to 18 cm high.

9.6.18 If the nicotine peak is off-scale, raise the collector height one division. Repeat the injection and adjust as necessary.

9.6.19 Inject 2 µL aliquot of each nicotine standard.

9.6.20 Determine the peak area ratios of nicotine to internal standard.

9.6.21 On graph paper, plot the standard peak area ratios versus concentration. This must be a straight line.

9.6.22 If non-linear, raise the voltage and repeat. Do not go any higher than 22 or 23 volts - instead replace the collector.

9.6.23 Because the N/P detector can become non-linear as the collector ages, a linearity check (9.6.21) must be performed at the beginning of each day.

9.6.24 When the N/P detector is not going to be used for a long period (over four days), reduce the voltage to about 14 volts.

9.6.25 If the N/P detector is not going to be used for a short while (less than four days), do not change the voltage setting.

9.6.26 Do not turn off the collector voltage except to change septums and columns, etc.

9.7 How to replace the collector in the nitrogen/phosphorous detector (Hewlett-Packard Model 18789A).

9.7.1 Turn off the voltage switches on the control module. (See Figure 4.)

9.7.2 Turn off the hydrogen and air toggle valves on detector.

9.7.3 Remove the detector cover by loosening two retaining screws.

9.7.4 Loosen the two collector lock screws. (See Figure 5.)

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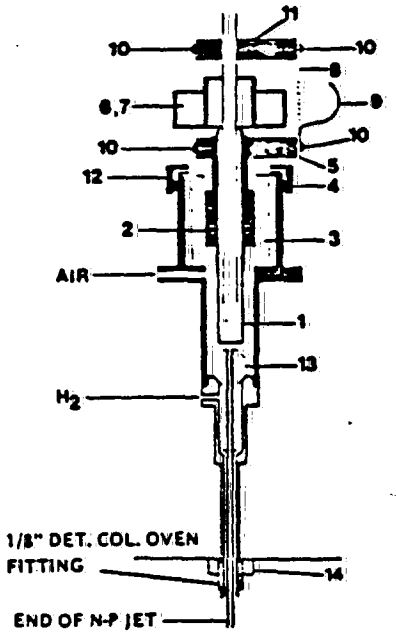
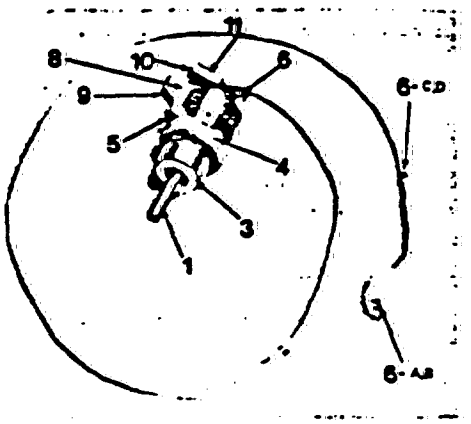
FIGURE 5

N-P CHIMNEY ASSY.





Item	Description	Part Number	Qty
1	Collector N-P (shown)	18789-60040	*
	Collector, Autoignition (supplied)	18789-60080	*
	Collector, Manual (supplied)	18789-20170	*
2	O-ring	0905-0111	1
3	Insulator	18789-60150	1
4	Knurled Nut (brass)	18789-20110	1
5	Bottom Clamp	18789-20070	1
6	Toroid Assy.	18789-60050	1
A	• Connector	1251-3407	1
B	• Contact	1251-0667	2
C	• Wire Marker A	7120-5376	2
D	• Wire Marker B	7120-5377	2
7	Flat Head Screw, 4-40 x 0.25	2200-0165	2
8	Link Strap	18789-00060	1
9	Contact	18789-20150	1
10	Pan Head Screw, 4-40 x 0.25	2200-0139	4
11	Top Clamp	18789-20060	1
12	Spring (Wave) Washer	2190-0174	1
13	N-P Jet (long-small bore)	18789-20190	*
	N-P Jet (long-large bore)	18789-80060	*
14	Brass Nut, 5/16-20	0590-0385	1

Two (2) each are provided with the detector or installation kit.

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9.7.5 Hold the top clamp to one side and pull the collector out with a pair of needle-nose pliers.

9.7.6 Install the replacement collector; push the collector down as far as possible then pull it up three divisions.

9.7.7 Small adjustments can be made to the collector to fine tune the detector when other operating conditions are established.

9.7.8 Tighten the collector lock screws.

9.7.9 Replace the detector cover.

9.7.10 Turn on the hydrogen and air toggle valves on the detector.

9.7.11 Continue as in Section 9.6.2.

9.8 Automatic Sampler Set Up

9.8.1 Install the automatic sampler to inject into the "A" injector (front).

9.8.2 Adjust Stop 1 to inject about 2 µL.

9.8.3 Install a clean syringe in the sampler.

9.8.4 Load the sample vials into the sample cartridge, insert the sample cartridge into the injector and lock in place. Do not put samples in positions 98 and 99.

9.8.5 Start the injection sequence by depressing the run button.

9.8.6 The sampler will start after a time delay.

9.9 Sample Analyses

9.9.1 Cambridge pads are received from the smoke laboratory after they have been transferred to stoppered sample vials.

9.9.2 The sample vials are placed in the "dry-box" where 20 mL of extracting solution is added by means of an auto-pipette. Stopper.

9.9.3 The vials are then shaken for 15 minutes on an up and down shaker.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

9.9.4 The vials are removed from the shaker and placed in the "dry box."

9.9.5 Approximately 1 mL aliquots are transferred to the sample vials and capped with a Teflon lined septum cap.

9.9.6 The sample vials are placed in the auto injector sample cartridge.

9.9.7 After every 20 samples, a nicotine control and a water control are analyzed. See Section 11.

10. Calculations

10.1 Determine the areas of the nicotine and water peaks and their appropriate internal standards.

10.2 Calculate the peak area ratios for nicotine to internal standard and for water to internal standard.

10.3 Using the regression equation (determined during standardization), substitute peak area ratios for Y. The value for X will be the amount of nicotine or water.

10.4 Standardization Example

10.4.1 The following peak areas were measured for the water standards:

Standard	Water	Int. Std.
Blank	5,008	49,500
0.5 mg/cig.	10,017	49,648
1.0	16,111	50,513
2.0	25,971	49,479
3.0	36,232	51,217
4.0	45,196	48,921
Blank	4,991	49,427
0.5 mg/cig.	11,131	49,693
1.0	15,917	50,121
2.0	27,119	49,610
3.0	35,013	51.104
4.0	43,991	48,617

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10.4.1 The following peak areas were measured for the nicotine standards:

Standard	Nicotine	Int. Std.
Blank	022	97,017
0.10 mg/cig.	5,092	105,094
0.50	24,963	96,958
1.00	45,029	87,111
2.00	105,991	101,091
Blank	012	95,912
0.20	4,897	104,892
0.50	25,103	105,227
1.00	44,971	86,897
2.00	106,171	100,961

10.4.2 The peak area ratios are calculated as follows:

$$\frac{\text{Peak Area (Water or Nicotine)}}{\text{Peak Area (Internal Standard)}} = \text{Peak Area Ratio}$$

10.4.3 The peak area ratios for the standards are as follows:

Standard	Water	Standard	Nicotine
Blank	0.10	Blank	0.00
0.5 mg/cig.	0.20	0.1 mg/cig.	0.05
1.0 mg/cig.	0.32	0.5 mg/cig.	0.26
2.0 mg/cig.	0.52	1.0 mg/cig.	0.52
3.0 mg/cig.	0.71	2.0 mg/cig.	1.05
4.0 mg/cig.	0.92	Blank	0.00
Blank	0.10	0.1 mg/cig.	0.05
0.5 mg/cig.	0.22	0.5 mg/cig.	0.24
1.0 mg/cig.	0.32	1.0 mg/cig.	0.52
2.0 mg/cig.	0.55	2.0 mg/cig.	1.05
3.0 mg/cig.	0.69		
4.0 mg/cig.	0.90		

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10.4.4 Perform least squares linear regression on the above data and determine the correlation coefficient, Y-intercept and slope.

	Water	Nicotine
Y-intercept	0.112	-0.005
Slope	0.200	0.526
Corr. Coeff.	0.999	0.999

10.4.5 The standard equations are determined by substituting the above values for the slope and the Y-intercept in the following equation.

$$X = \frac{Y - (Y\text{-Intercept})}{\text{Slope}}$$

where: X = the amount of water or nicotine
Y = peak area ratio of water or nicotine

10.4.6 Thus:

$$\text{Water} = \frac{\text{Peak Area Ratio} - 0.112}{0.200}$$

$$\text{Nicotine} = \frac{\text{Peak Area Ratio} + 0.005}{0.526}$$

10.5 Sample Analyses:

10.5.1 See Section 10.1 and 10.2

10.5.2 Using the equations set up in Section 10.4.6, substitute the peak areas and solve. The results are in mg/cig.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

11. Quality Control Procedure

11.1 Nicotine/Water Chemical Control

11.1.1 After every 20 samples, a nicotine and a water control are analyzed.

11.1.2 These controls are the 1 mg nicotine standard and the 1 mg water standard.

11.1.3 Sections 7.3 and 7.4 describe how to make these controls.

11.1.4 The results of the analysis of these controls must agree within specified limits set for this method by the statistician and laboratory supervisor.

11.1.5 If the results fall outside the limits, the method is declared out of control and the analyses must be repeated.

11.1.6 If the results continue to fall outside the limits during repeat analyses, consult Section 12 for remedial action.

11.1.7 If no change in the results are noted after the application of the procedures in Section 12, shut the method down and notify the Manager of Analytical Methods Development.

11.2 Nicotine/Water Smoke Control (Referee)

11.2.1 Two referee samples are smoked per run on a Philip Morris Smoking machine. A "high" level referee - about 12 mg tar with 1 mg nicotine and a "low" level referee with about 5 mg tar with 0.6 nicotine.

11.2.2 These referee samples are analyzed and the nicotine and water results must fall within a specified range determined by the standard deviation of a number of samples analyzed on different days.

11.2.3 If the results are out of range, the Gas Chromatography Laboratory Supervisor should consult with the Smoking Laboratory Supervisor to determine if there was a variance in the smoking run.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

11.2.4 If there was a variance during the smoking run, and a repeat analysis of the referee samples shows the results still out of range - the sample must be discarded and the smoking run repeated.

11.2.5 If there was no variance during the smoking run and a repeat analysis still shows the results out of range - consult Section 12 for remedial action.

11.2.6 If following the suggestions in Section 12 results in no significant changes in the results, shut down the method and notify the Manager of Analytical Methods Development.

12. Operational Notes

12.1 The glass liner and septum for "A" injection port should be changed at the beginning of the day. The columns should be at room temperature and the N-P detectors must be turned off during the change.

12.2 The linearity of the N-P detector should be checked at the beginning of each day by injecting each standard in order and plotting the peak area ratios of nicotine to the internal standard versus concentration.

12.3 Good chromatographic practice demands that, when unfamiliar samples are to be analyzed, a preliminary sample containing no internal standard be analyzed to determine if a compound is present that would interfere with the internal standard.

12.4 As the N-P collector ages, the detector response decreases; however, the peak area ratio (nicotine to internal standard) does not change. Changing the attenuation will compensate for this loss. A typical collector can be expected to last from two weeks to three weeks.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

12.5 The upper end of the N-P collectors has division marks to aid in adjustment. Each division = 0.025". To adjust the collector, loosen the two lock screws; push collector down as far as possible, then pull it up three divisions. Tighten lock screws.

12.6 We strongly recommend the use of a carrier gas purifier to reduce the amount of oxygen and water in the carrier gas to less than 1 ppm. This will greatly increase column life. We recommend a unit such as the Supelco Carrier Gas Purifier Catalog #2-3800.

12.7 This is the standardization procedure recommended for use with the PAMILA computer system:

12.7.1 After conditioning the column system, standardize using three injections of each: the combined solvent blank - 0.1 mg/cig. nicotine standard solution, and the combined 3.0 mg/ig. water standard -1.5 mg/cig. nicotine standard solution.

12.7.2 After standardization is complete, inject each standard in order to determine response.

2023100202

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

APPENDIX I

PROCEDURE FOR THE DISTILLATION OF NICOTINE

1. The following equipment is needed:
   - 1.1 Heated three-neck round bottom flask - 250 mL - Ace Glass Company, Catalog #9642-112.
   - 1.2 Controller for heated flask (above) - Ace Glass Company, Catalog #9698-15.
   - 1.3 Connecting cord for heated flask - Ace Glass Company, Catalog #9698-15.
   - 1.4 Distilling receiver - Ace Glass Company, Catalog #9400-10.
   - 1.5 Distilling column - Ace Glass Company, Catalog #9351-06.
   - 1.6 Condenser, West type, 120 mm long Ace Glass Co. Catalog #9299-08.
   - 1.7 Magnetic stirrer - Fisher Catalogue #14-493-120 MR.
   - 1.8 Adapter (2) - Ace Glass Company, Catalog #5028-28.
   - 1.9 Thermometer (0-250°C) - Ace Glass Company, Catalog #9553-04.
   - 1.10 Thermometer (-10 to + 250°C) - Ace Glass Company, Catalog #8285-16.
   - 1.11 Vacuum trap (2) - Ace Glass Company, Catalog #8753-12.
   - 1.12 DeWar Flask (2) - Ace Glass Company, Catalog #2540-07.
   - 1.13 Needle valve (bottom of a Fisher burner) - Fisher, Catalog #03-902.
   - 1.14 Manometer - McLeod (5 um to 5 mm) - Fisher, Catalog #10-269-27.
   - 1.15 Teflon sleeves - Fisher, Catalog #14-320D.
   - 1.16 Vacuum pump - Welch from Fisher, Catalog #01-096.
   - 1.17 T-Shaped Connectors, Glass, 5/10" O.D. - Fisher Scientific, Catalog #15-328B.
   - 1.18 Storage vials, 1 mL capacity - Preiser, Catalog #10-4788-12.
   - 1.19 Caps for 1 mL vials - Preiser, Catalog #10-4805-29.
   - 1.20 Crimper for above caps - Preiser, Catalog #10-4814-13.

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1.21 Large storage vials with caps, 50 mL capacity - Preiser, Catalog #72-4708-53.

1.22 Transfer syringe, 2 mL capacity - Preiser, Catalog #14-4249-17.

1.23 Needles for above, No. 18, 2" - Preiser, Catalog #14-4261-52.

1.24 Regulator, Dual Stage Brass, for nitrogen - Matheson, Catalog 3104-580.

1.25 Needle valve - for regulator above - Nupro, Catalog-Ss-2-25

2. Supplies

2.1 Nicotine, Reagent Grade, 98% purity - Eastman Organic Chemicals, Catalog #1242.

2.2 Vacuum grease, Apiezon T - Fisher Scientific Company, Catalog #14-638-15E.

2.3 Rubber tubing, ½" base x ¼" wall - Preiser Scientific, Catalog #13-8874-13.

2.4 Magnetic stirring bar (1"), Teflon Coated - Fisher Scientific, Catalog #14-511-63.

2.5 Nitrogen, gas cylinder - Prepurified Grade from Matheson.

3. Safety Requirements

NOTE: NICOTINE IS A POISON AND SHOULD BE HANDLED WITH CARE!

3.1 This equipment should be set up in a well ventilated hood that has a glass safety shield.

3.2 There should be two technicians present at all times when the distillation is in process.

3.3 Technicians must wear safety glasses with side shields or full face safety shields.

3.4 Technicians must wear rubber gloves when handling nicotine.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

4. Equipment Set-up

4.1 All glassware should be cleaned in a chromic acid solution, rinsed in distilled water and dried in an oven before use.

4.2 Assemble equipment as shown in Figure 1 using the Teflon sleeves to minimize the use of vacuum grease.

4.3 Test system for leaks by closing needle valve on nitrogen inlet, starting vacuum pump and gradually closing the system needle valve. It is not necessary to have dry ice/acetone mixture in the DeWar flasks.

4.4 Using the McLeod gauge, the vacuum should be less than 0.5 mm Hg.

5. Distillation Procedure

5.1 Carefully add the contents of a 100 g bottle of nicotine to the distillation flask.

5.2 Add a stirring bar and start the stirring motor.

5.3 Purge the system with N_2 and adjust flow to about 1-2 mL/min.
NOTE: Keep gas delivery tube ABOVE the surface of the liquid.

5.4 Add dry ice and acetone to the two vacuum traps in the DeWar flasks.

5.5 Make sure that the system needle valve is open and turn on the cooling water to condenser.

5.6 Start the vacuum pump and gradually close the system needle valve.

5.7 Check the vacuum frequently with the McLeod gauge.

5.8 When the vacuum stabilizes, adjust the vacuum level to 1 mm Hg by adjusting the flow of the nitrogen purge.

5.9 Gradually apply heat to the distillation flask.

5.10 Distillation will start at about 90°C. Distill at the rate of one drop every 15 seconds.

5.11 Depending on the pressure, nicotine will distill at 110-120°C.

5.12 Collect fractions and label with boiling range and pressure.

5.13 The residue remaining in the distilling flask should be weighed and transferred to an amber vial. A label should be placed on the vial stating nicotine residue and the weight. The vial should be returned to the Stockroom for disposal.

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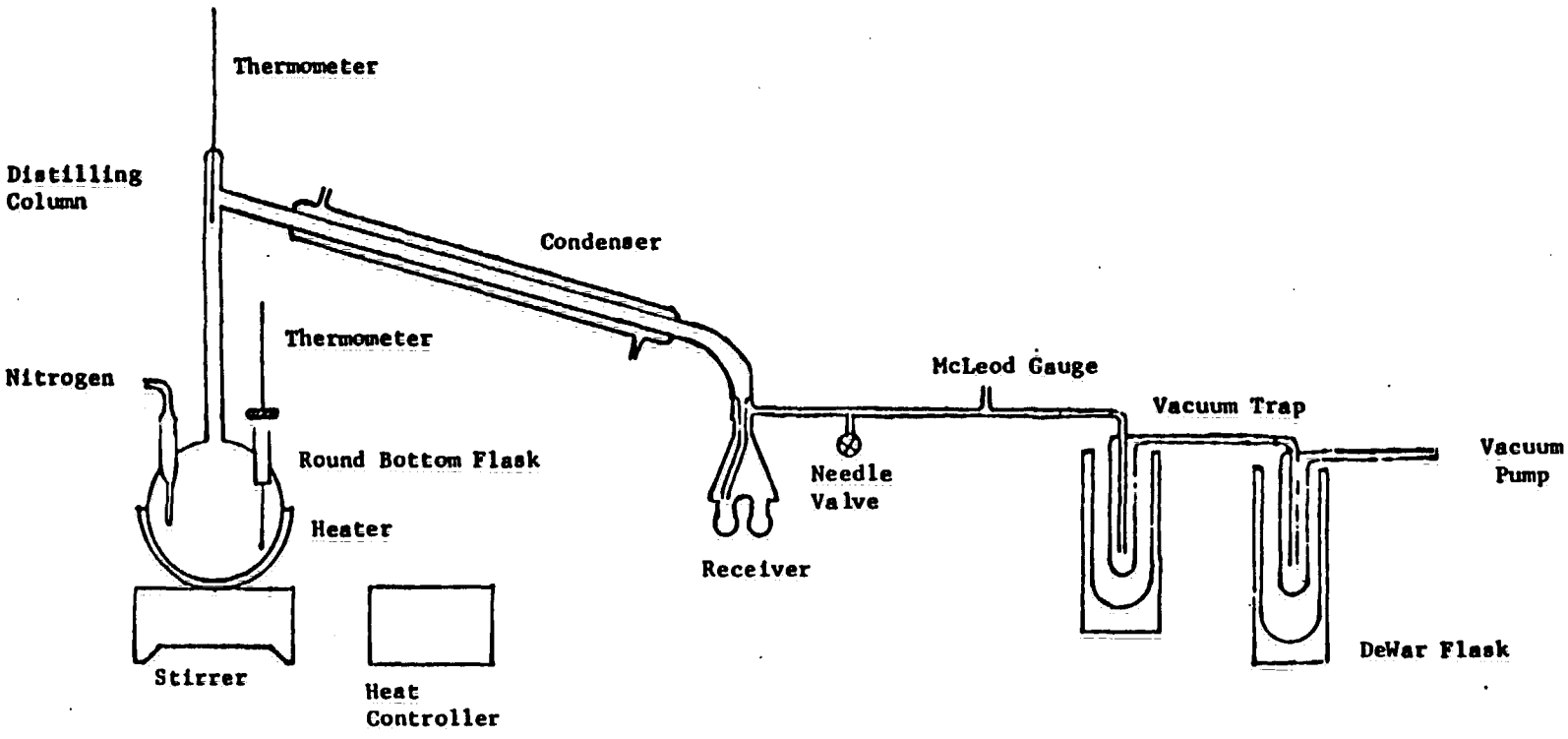
Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

FIGURE 1

EQUIPMENT SET-UP FOR NICOTINE DISTILATION



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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

6. Storage

6.1 After distillation, transfer the distilled nicotine using a glass syringe with a No. 18 or 20 needle to septum vials.

6.2 Purge the vials with nitrogen and close with a Teflon lined cap.

6.3 Store three or four vials in a larger screw cap vial that has been purged with nitrogen.

6.4 Carefully label showing date, temperature range, pressure, and person carrying out distillation.

6.5 Wrap the container in aluminum foil and store in the dark in a freezer.

6.6 The the samples will remain colorless for about six months if stored under these conditions.

2023100207

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

APPENDIX II

HOW TO PACK A GAS CHROMATOGRAPHY COLUMN

NOTE: This procedure describes how to pack efficient gas chromatography columns. However, we recommend that the columns be purchased prepacked and preconditioned from:

Alltech Associates
202 Campus Drive
Arlington Heights, IL 60004

1. The following supplies are needed:

NOTE: These are available from chromatography supply houses such as:

Supelco, Inc.
Bellefonte, PA 16823

Analabs
80 Republic Drive
North Hover, CN 06473

Applied Science Division
Milton Roy Company
P. O. Box 440
State College, PA 16801

Alltech Associates
202 Campus Drive
Arlington Heights, IL 60004.

1.1 GC grade tubing
1.2 Swagelok nuts
1.3 Graphlok ferrules
1.4 Leak detector - "Snoop"

2023100208

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

1.5 Tubing cutter

1.6 Tubing reamer

1.7 Triangular file

1.8 Silane Treated glass wool

1.9 Column filling funnel

1.10 Vibrator

1.11 Column trap

1.12 Column end caps

1.13 Stopwatch

1.14 Bubble flow-meter

2. Procedure

2.1 Cut tubing to the desired length. File the ends smooth and open the end of the tubing using a reamer.

2.2 Wash the tubing using the following sequence and amounts of solvent (use vacuum to pull solvents through tubing):

	Solvent	Amount
1.	Chloroform	50 mL
2.	Methanol	25 mL
3.	Water	50 mL
4.	Acetone	25 mL
5.	Methanol	50 mL

2.3 Dry the column with a stream of nitrogen.

2.4 If possible, pack the column straight then coil into largest diameter coil possible to fit into the oven. For packings, see Section 4.

2.5 Insert a plug of silane treated glass wool in one end of the column. A straightened paper clip can be used for this.

2.6 Attach a vacuum line to the end containing the glass wool plug.

2.7 Attach a small funnel using rubber tubing on the other end of the column.

2.8 Add column packing to the funnel and apply vacuum to the opposite end. Vibrate.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

2.9 When the column is full, remove the funnel and close the column with a plug of silane treated glass wool.

2.10 Coil columns to the desired diameter.

2.11 Use brass Swagelok nuts and Graphlok ferrules to attach the column to the gas chromatograph.

2.12 Attach the end of the column where it was filled to the outlet of the injector. Check for leaks.

2.13 Attach a short length (12") of 1/16" tubing to the column outlet. This is to prevent back-streaming of air into the column during conditioning. Do not attach the column to the detector.

2.14 Set the carrier gas flow as described in the method using a bubble flow meter connected to the 1/16" tubing on column outlet.

2.15 Attach a tag to the column with the following information:

Column diameter and length:
Loading level and stationary phase:
Support and particle size:
When packed and by whom:

2.16 Columns can be conditioned in advance but must be tightly sealed and stored under nitrogen.

3. Column Conditioning

3.1 Allow the carrier gas to flow through the column at room temperature for 30-45 minutes to remove trapped air.

3.2 Program the temperature from 50°C to operating temperature +10°C at 1-2° per minute and hold overnight.

3.3 The upper temperature limit should be held three to six hours.

3.4 Columns can be conditioned faster using very high carrier gas flow (50-80 cc/min.), reducing the initial period to 15 minutes, programming at 8°/minute and holding at the upper limit, operating temperature +20°C, for about one hour. This column will have shorter life and reduced resolution.

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4. Column Packings

The column packings listed below are available from Alltech Associates:

4.1 10% Carbowax 20M + 2% KOH on Chromosorb W Acid Washed 80/100 mesh. Catalog #8412

4.2 Porapak Q porous polymer 50/80 mesh. Catalog #2700

5. Prepacked Columns

5.1 Excellent quality prepacked, preconditioned columns are available from:

Alltech Associates
202 Campus Drive
Arlington Heights, IL 60004
Phone 312-392-2670

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APPENDIX III

PROCEDURE FOR ANALYZING NICOTINE SAMPLES OUTSIDE THE RANGE OF 0.1 TO 1.5 MILLIGRAMS PER CIGARETTE

1. Procedure to measure nicotine in samples containing more than 1.5 mg/cig.

   1.1 No changes in the methodology are needed except that the sample should be diluted with extracting solution until the analytical result is less than 1.5 mg/cig. The result is then multiplied by the dilution factor to determine the nicotine level.

   Example:
   A sample is analyzed and the nicotine result is 2.6 mg/cig. From this it appears that the sample should be diluted one to two. Pipette a 5 mL aliquot of the sample into a 10 mL volumetric flask and dilute to volume with extracting solution. Mix well. Analyzing the diluted sample yielded a result of 0.88 mg/cig. Multiply this result by the dilution factor of two to obtain the final result of 1.76 mg/cig.

2. Procedure to determine nicotine in samples containing between 0.01 and 0.2 mg/cig. nicotine.

   2.1 The changes in the methodology needed to analyze samples in this range are: (1) the extracting solution, (2) the standards, and (3) the electrometer attenuator setting for the nitrogen/phosphorous detector.

   2.2 Extracting Solution
   Reduce quinoline to 0.5 mL per gallon of isopropanol. Reduce methanol to 4 mL per gallon. Stopper and shake well.
   Concentration = quinoline 146 µg/mL and methanol 850 µg/mL.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

2.3 Nicotine standards:

2.3.1 Using the nicotine stock standards made in Section 7.3.2, pipette 5 mL of each standard into 50 mL volumetric flasks and dilute to volume with isopropanol that does not contain any internal standards. Concentration = 50, 250, 500 and 1000 µg/mL.

Label: Nicotine Stock Standard
Concentration -
Date -
Technician -

2.3.2 Pipette 2 mL of each Stock Standard into four extraction vials which contain two whole and two quarter Cambridge pads. Prepare a fifth vial as a blank. Add 20 mL of extracting solution to each vial. Stopper and shake 15 minutes on the up and down extractor. Concentration = 100, 500, 1000, and 2000 µg per vial which is equal to (assuming five cigarettes smoked per pad and two pads are extracted/vial) 0.01, 0.05, 0.10 and 0.20 mg/cig.

Label: Nicotine Working Standard
Concentration -
Date -
Technician Name -

2.3.4 Transfer an aliquot from each vial to an auto sampler vial and seal. Set the auto injector to "maximum" wash between samples.

2.3.5 Standardize the instrument as outlined in this methodology, Section 8. Adjust the attenuator as necessary.

2.3.6 Analyze samples as outlined in Section 9.8.

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3. Procedure to analyze nicotine in samples containing between 0.001 and 0.02 mg/cig.

3.1 To analyze samples at this level, the instrument must be operated near its maximum sensitivity settings. The baseline from the nitrogen/phosphorous detector will be "noisy". All glassware must be thorougly rinsed with distilled water because detergent residues may contain phosphorous compounds which would interfere with the N/P detector.

3.2 The changes in methodology necessary to analyze samples in this range are: (1) extracting solution, (2) standards, (3) electrometer settings and (4) autosampler set-up.

3.3 Extracting Solution

Reduce quinoline to 0.05 mL per gallon of isopropanol. There is no need to add an internal standard for water because this method cannot measure water at very low levels. Use the Karl Fischer method to measure water at these levels.

3.4 Nicotine Standards

3.4.1 Using the nicotine stock standards made in Section 7.3.2, pipette 1 mL of each standard into 100 mL volumetric flasks and dilute to volume with isopropanol that does not contain any internal standard. Concentration = 5, 25, 50, and 100 µg/mL.

Label: Nicotine Stock Standard
Concentration -
Date -
Technician Name -

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

3.4.2 Pipette 2 mL of each Stock Standard into four extraction vials which contain two whole and two quarter Cambridge pads. Prepare a fifth vial also containing Cambridge pads as a blank. Add 20 mL of extracting solution to each vial. Stopper and shake 15 minutes on the "up and down" extractor. Concentration equals (assuming five cigarettes smoked per pad and two pads are extracted per vial) 0.001, 0.005, 0.01 and 0.02 mg/cig.

Label: Nicotine Working Standard
Concentration -
Date -
Technician Name -

3.4.3 Transfer an aliquot from each vial to an auto sampler vial and seal. Set the auto sampler to "maximum" wash between samples. Between each sample or standard vial, place a vial of absolute methanol to act as a solvent wash to prevent sample transfer which occurs at these very low levels.

3.4.4 Standardize the instrument as outlined in this methodology, Section 8. Adjust the attenuator as necessary.

3.4.5 Analyze samples as outlined in Section 9.8.

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APPENDIX IV

DATA FROM NICOTINE BIAS AND PRECISION STUDY

AUTOANALYZER VERSUS GAS CHROMATOGRAPH

2023100216

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

2

BRAND DESCRIPTION		PAD ANALYSIS			FILTER ANALYSIS					
		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
B&H MENTHOL 100										
	BY AA	9	1.086	0.052						
	BY GC	9	1.114	0.086						
	MEAN BIAS	9	-0.028	0.065						
BARCLAY BOX, PETERSBURG										
	BY AA	249	0.192	0.061	167	0.445	0.092	161	73.042	3.684
	BY GC	248	0.201	0.077	167	0.5310	.129	167	74.856	4.638
	MEAN BIAS	242	-0.012*	0.031	167	-0.066*	0.061	161	-1.765	2.701
BARCLAY MENTHOL 100, LOUISVILLE										
	BY AA	115	0.322	0.083	97	0.339	0.043	97	52.439	4.444
	BY GC	115	0.325	0.089	97	0.3560	.049	97	53.654	5.334
	MEAN BIAS	115	-0.003	0.028	97	-0.016*	0.033	97	-1.215	2.419
BARCLAY MENTHOL 100, PETERSBURG										
	BY AA	104	0.373	0.069	42	0.409	0.044	42	51.499	3.985
	BY GC	103	0.417	0.077	34	0.4540	.050	33	51.325	4.566
	MEAN BIAS	103	-0.044*	0.030	34	-0.042*	0.028	33	0.426	2.137
BARCLAY MENTHOL, LOUISVILLE										
	BY AA	83	0.132	0.074	72	0.288	0.044	70	69.871	4.793
	BY GC	84	0.115	0.070	72	0.3120	.046	72	74.388	4.399
	MEAN BIAS	83	0.017*	0.016	72	-0.024*	0.026	70	-4.509	2.451
BARCLAY MENTHOL, PETERSBURG										
	BY AA	98	0.189	0.047	47	0.383	0.061	46	68.922	3.949
	BY GC	96	0.180	0.050	39	0.3860	.052	39	70.236	3.476
	MEAN BIAS	94	0.007*	0.028	39	-0.002	0.040	38	-1.248	3.762
[illegible]AY 100, LOUISVILLE										
	BY AA	183	0.344	0.071	144	0.355	0.041	143	51.056	3.269
	BY GC	179	0.335	0.063	132	0.3580	.043	127	52.310	3.927
	MEAN BIAS	179	0.009*	0.053	132	-0.003	0.039	127	-1.275	2.765
BARCLAY, LOUISVILLE										
	BY AA	124	0.161	0.054	89	0.410	0.083	85	72.236	4.264
	BY GC	128	0.139	0.053	89	0.4590	.084	89	76.872	4.330
	MEAN BIAS	122	0.020*	0.026	89	-0.049*	0.042	85	-4.600	2.613
BARCLAY, PETERSBURG										
	BY AA	231	0.175	0.052	142	0.426	0.074	135	72.631	4.172
	BY GC	240	0.175	0.063	142	0.4780	.102	142	75.378	4.595
	MEAN BIAS	231	-0.002	0.029	140	-0.055*	0.053	133	-2.590	2.799
BCR - 2										
	BY AA	378	0.254	0.077	317	0.593	0.074	302	70.760	4.240
	BY GC	383	0.244	0.064	298	0.6430	.081	290	73.167	4.309
	MEAN BIAS	369	0.008*	0.043	298	-0.052*	0.065	280	-2.276	3.089
BELAIRE 100, PETERSBURG										
	BY AA	39	0.840	0.127	33	0.575	0.045	33	40.786	3.294
	BY GC	39	0.825	0.142	33	0.5100	.042	33	38.500	3.509
	MEAN BIAS	39	0.015	0.049	33	0.064*	0.031	33	2.285	1.679
BELAIRE, MACON										
	BY AA	16	0.702	0.053	8	0.745	0.027	8	50.993	1.731
	BY GC	13	0.749	0.059	8	0.7020	.018	5	50.070	1.941
	MEAN BIAS	13	-0.060*	0.040	8	0.043*	0.016	5	1.910	0.732
BELAIRE, PETERSBURG										
	BY AA	11	0.743	0.045	11	0.732	0.036	11	49.645	1.916
	BY GC	11	0.734	0.062	11	0.7030	.040	11	48.968	2.634
	MEAN BIAS	11	0.009	0.045	11	0.029*	0.032	11	0.677	1.489

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

BRAND DESCRIPTION		PAD ANALYSIS			FILTER ANALYSIS					
		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
BROADWAY 80 ISRAEL										
	BY AA	8	1.095	0.054	8	0.559	0.039	8	33.771	1.153
	BY GC	8	0.974	0.052	8	0.3770	0.029	8	27.943	1.844
	MEAN BIAS	8	0.121*	0.047	8	0.181*	0.016	8	5.828	0.902
CAMBRIDGE KS										
	BY AA	8	0.104	0.047	10	0.434	0.049	6	82.633	4.216
	BY GC	13	0.080	0.031	7	0.4470	0.060	6	86.450	1.319
	MEAN BIAS	8	0.022*	0.025	7	-0.020	0.037			
CAMEL FILTER										
	BY AA	8	1.120	0.101	8	0.701	0.035	8	38.575	1.424
	BY GC	8	1.092	0.075	8	0.6470	0.044	8	37.230	1.711
	MEAN BIAS	8	0.028	0.069	8	0.054*	0.024	8	1.345	1.491
CARLTON KS										
	BY AA	7	0.149	0.018	10	0.432	0.041	7	73.551	2.518
	BY GC	10	0.122	0.020	10	0.4170	0.036	10	77.380	3.073
	MEAN BIAS	7	0.036*	0.018	10	0.015	0.031	7	-4.697	3.344
DOUBLE HAPPINESS KS, HONG KONG										
	BY AA	8	1.869	0.139	8	0.859	0.055	8	31.506	1.196
	BY GC	8	1.841	0.078	8	0.7020	0.059	8	27.607	1.949
	MEAN BIAS	8	0.028	0.086	8	0.156*	0.029	8	3.900	1.095
DU MAURIER, LOUISVILLE										
	BY AA	19	1.022	0.100	12	0.665	0.056	12	39.763	4.153
	BY GC	16	0.977	0.122	12	0.5750	0.080	9	36.641	4.949
	MEAN BIAS	16	0.044*	0.065	12	0.090*	0.111	9	4.013	0.629
EUROPA 80 ISRAEL										
	BY AA	8	1.174	0.084	8	0.739	0.046	8	38.642	0.455
	BY GC	8	1.080	0.065	6	0.6100	0.042	6	36.300	1.172
	MEAN BIAS	8	0.094*	0.067	6	0.137*	0.025	6	2.359	1.351
GOLDEN LIGHTS KS										
	BY AA	16	0.667	0.043	13	0.552	0.038	13	45.631	1.774
	BY GC	13	0.723	0.107	8	0.5170	0.038	8	42.251	5.471
	MEAN BIAS	13	-0.047	0.111	8	0.054*	0.039	8	4.191	4.380
GOLDEN LIGHTS 100										
	BY AA	16	0.672	0.099	16	0.593	0.091	16	46.861	2.032
	BY GC	12	0.710	0.092	12	0.5420	0.091	11	42.885	3.971
	MEAN BIAS	12	-0.046	0.092	12	0.067*	0.033	11	4.787	3.670
KENT DELUXE 100										
	BY AA	16	1.200	0.115	16	0.594	0.036	16	33.196	1.320
	BY GC	11	1.241	0.166	13	0.5110	0.027	11	29.008	2.439
	MEAN BIAS	11	-0.064*	0.079	13	0.090*	0.020	11	4.499	1.440
KENT GOLDEN LIGHTS KS, PETERSBURG										
	BY AA	41	0.555	0.084	37	0.502	0.046	37	47.278	2.616
	BY GC	41	0.540	0.096	34	0.4830	0.049	34	47.764	3.044
	MEAN BIAS	41	0.015*	0.037	34	0.019*	0.026	34	-0.184	1.423
KENT GOLDEN LIGHTS 100, PETERSBURG										
	BY AA	18	0.748	0.065	18	0.678	0.041	18	47.577	2.117
	BY GC	17	0.718	0.081	18	0.6460	0.035	17	47.423	2.565
	MEAN BIAS	17	0.026*	0.034	18	0.032*	0.015	17	0.243	1.363
KENT GOLDEN LIGHTS 80, FINLAND										
	BY AA	5	0.710	0.069	5	0.476	0.035	5	40.182	2.353
	BY GC	5	0.836	0.072						
	MEAN BIAS	5	-0.126	0.120						

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

B DESCRIPTION		PAD ANALYSIS			FILTER ANALYSIS					
		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
KENT GOLDEN LIGHTS BO, PETERSBURG										
	BY AA	16	0.693	0.118	14	0.650	0.052	14	48.768	3.299
	BY GC	16	0.657	0.119	14	0.6180	0.069	14	49.043	3.982
	MEAN BIAS	16	0.036*	0.042	14	0.032*	0.042	14	-0.294	1.885
KENT III KS										
	BY AA	16	0.276	0.032	13	0.495	0.044	13	64.163	2.381
	BY GC	16	0.244	0.021	13	0.5050	0.032	13	67.630	2.304
	MEAN BIAS	16	0.032*	0.031	13	-0.010	0.029	13	-3.468	2.775
KENT KS, AUSTRALIA										
	BY AA	13	1.158	0.057	11	0.707	0.027	11	37.903	1.568
	BY GC	13	1.070	0.062	11	0.5530	0.093	11	34.159	3.684
	MEAN BIAS	13	0.088*	0.064	11	0.155*	0.080	11	3.745	2.953
KENT KS, PETERSBURG										
	BY AA	23	0.963	0.082	19	0.657	0.029	19	40.734	2.159
	BY GC	23	0.958	0.098	16	0.5790	0.057	16	38.595	1.524
	MEAN BIAS	23	0.005	0.063	16	0.077*	0.048	16	2.577	1.675
KENT MIC. II 100, PETERSBURG										
	BY AA	5	1.146	0.050	5	0.638	0.062	5	35.722	2.363
	BY GC	5	1.102	0.046	5	0.5100	0.021	5	31.645	1.085
	MEAN BIAS	5	0.044	0.043	5	0.128*	0.052	5	4.076	1.491
KENT MIC. II, PETERSBURG										
	BY AA	5	0.986	0.099						
	BY GC	5	1.012	0.075						
	MEAN BIAS	5	-0.026	0.040						
KENT MIC. 100, PETERSBURG										
	BY AA	5	1.120	0.031						
	BY GC	5	1.204	0.113						
	MEAN BIAS	5	-0.084	0.111						
KENT MICRONITE II KS										
	BY AA	16	0.973	0.076	13	0.615	0.035	13	38.676	1.360
	BY GC	16	0.964	0.078	13	0.5280	0.048	13	35.182	2.367
	MEAN BIAS	16	0.009	0.034	13	0.088*	0.043	13	3.494	1.442
KENT BO, AUSTRALIA										
	BY AA	5	1.006	0.194						
	BY GC	5	0.864	0.202						
	MEAN BIAS	5	0.142*	0.104						
KENT BO, AUSTRIA										
	BY AA	24	1.114	0.201	12	0.651	0.054	12	39.143	1.026
	BY GC	24	1.045	0.192	12	0.5600	0.045	12	36.734	1.646
	MEAN BIAS	24	0.068*	0.048	12	0.091*	0.046	12	2.409	1.297
KENT BO, FINLAND										
	BY AA	5	0.974	0.237	5	0.548	0.131	5	36.053	1.977
	BY GC	5	1.036	0.213						
	MEAN BIAS	5	-0.062	0.101						
KOOL BOX 1/4-1/14 4%ET, PETERSBURG										
	BY AA	8	1.181	0.070	8	0.677	0.051	8	36.439	1.703
	BY GC	8	1.146	0.029	8	0.5490	0.045	8	33.129	1.714
	MEAN BIAS	8	0.035	0.070	8	0.109*	0.032	8	3.310	0.894
KOOL BOX 1/4-1/8 DET, PETERSBURG										
	BY AA	5	1.308	0.096						
	BY GC	5	1.100	0.094						
	MEAN BIAS	5	0.208*	0.019						
KOOL BOX 4%ET, PETERSBURG										

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

BRAND DESCRIPTION		PAD ANALYSIS			FILTER ANALYSIS					
		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
	BY AA	99	1.209	0.196	76	0.733	0.091	75	38.926	5.652
	BY GC	99	1.155	0.190	72	0.606	0.076	71	35.820	6.491
	MEAN BIAS	99	0.054*	0.054	72	0.131*	0.069	71	3.213	2.571
KOOL KING BXET, MACON										
	BY AA	80	1.151	0.202	64	0.673	0.090	64	37.860	4.474
	BY GC	80	1.109	0.196	61	0.534	0.074	61	33.695	5.200
	MEAN BIAS	80	0.042*	0.047	61	0.138*	0.050	61	4.298	1.905
KOOL KINGS 4XET, MACON										
	BY AA	8	1.116	0.103	8	0.655	0.087	8	36.937	2.662
	BY GC	8	1.126	0.095	8	0.602	0.054	8	34.914	3.528
	MEAN BIAS	8	-0.010	0.079	8	0.052*	0.042	8	2.023	1.556
KOOL KS, PANAMA										
	BY AA	8	1.152	0.058	8	0.604	0.035	8	34.371	0.616
	BY GC	8	1.129	0.071	8	0.497	0.035	8	30.600	1.533
	MEAN BIAS	8	0.024*	0.027	8	0.106*	0.037	8	3.771	1.637
KOOL KS, PHILLIPINES										
	BY AA	6	1.467	0.093						
	BY GC	6	1.275	0.112						
	MEAN BIAS	6	0.192*	0.134						
KOOL LIGHT 100 65M1, MACON										
	BY AA	16	0.960	0.079	16	0.708	0.037	16	42.518	2.681
	BY GC	16	1.065	0.092	8	0.749	0.030	8	42.523	1.508
	MEAN BIAS	16	-0.105*	0.027	8	-0.024*	0.016	8	1.658	0.514
KOOL LIGHT 100 95M1, MACON										
	BY AA	72	0.895	0.088	72	0.710	0.047	72	44.310	2.068
	BY GC	72	0.921	0.090	60	0.646	0.062	60	41.874	2.034
	MEAN BIAS	72	-0.026*	0.083	60	0.050*	0.054	60	2.501	2.256
KOOL LIGHT 100, PETERSBURG										
	BY AA	99	0.812	0.121	79	0.670	0.074	79	45.360	3.535
	BY GC	96	0.796	0.127	77	0.638	0.067	74	44.877	3.388
	MEAN BIAS	96	0.015*	0.066	77	0.031*	0.048	74	0.425	2.340
KOOL LIGHT, PETERSBURG										
	BY AA	34	0.726	0.080	29	0.792	0.065	29	52.087	2.009
	BY GC	31	0.711	0.074	29	0.759	0.065	26	51.590	3.596
	MEAN BIAS	31	0.012	0.038	29	0.033*	0.075	26	0.718	2.379
KOOL MILD 100, LOUISVILLE										
	BY AA	63	0.904	0.100	53	0.629	0.070	50	40.922	2.700
	BY GC	63	0.917	0.130	43	0.547	0.056	40	38.716	3.098
	MEAN BIAS	63	-0.013	0.085	43	0.083*	0.043	40	2.589	1.367
KOOL MILD, MACON										
	BY AA	42	0.848	0.145	35	0.766	0.085	34	46.784	2.761
	BY GC	38	0.812	0.120	34	0.672	0.084	29	44.578	3.534
	MEAN BIAS	38	0.018	0.070	34	0.096*	0.063	29	2.389	2.078
KOOL MILD, PETERSBURG										
	BY AA	29	0.923	0.089	18	0.752	0.069	18	44.781	3.595
	BY GC	29	0.903	0.095	18	0.644	0.061	18	42.040	2.998
	MEAN BIAS	29	0.020*	0.041	18	0.107*	0.054	18	2.741	2.179
KOOL REGULAR, LOUISVILLE										
	BY AA	15	1.163	0.095						
	BY GC	15	1.076	0.114						
	MEAN BIAS	15	0.087*	0.104						
KOOL SUPER LIGHT KS, FINLAND										
	BY AA	8	0.680	0.116						

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

BI DESCRIPTION / MRE		PAD ANALYSIS: NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	FILTER ANALYSIS: NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
	BY GC	8	0.645	0.125						
	MEAN BIAS	8	0.035*	0.036						
KOOL SUPERLIGHTS 100, PETERSBURG										
	BY AA	5	0.814	0.038	5	0.562	0.037	5	40.828	1.242
	BY GC	5	0.798	0.043	5	0.522	0.018	5	39.564	0.889
	MEAN BIAS	5	0.016*	0.011	5	0.040*	0.020	5	1.264	0.968
KOOL ULTRA 100, LOUISVILLE										
	BY AA	83	0.503	0.085	59	0.451	0.060	59	47.183	4.248
	BY GC	74	0.539	0.089	47	0.443	0.061	38	45.375	3.571
	MEAN BIAS	74	-0.048*	0.062	47	-0.020*	0.041	38	0.866	1.903
KOOL ULTRA, LOUISVILLE										
	BY AA	73	0.210	0.046	47	0.368	0.107	47	62.970	5.038
	BY GC	68	0.215	0.049	35	0.374	0.061	30	65.083	4.276
	MEAN BIAS	68	-0.007	0.034	35	-0.031*	0.037	30	-2.158	2.559
KOOL 100, MACON										
	BY AA	12	1.033	0.102	10	0.711	0.038	10	39.873	1.116
	BY GC	10	0.975	0.094	10	0.587	0.039	8	36.754	1.667
	MEAN BIAS	10	0.046*	0.051	10	0.124*	0.041	8	3.005	1.629
KOOL 100, PETERSBURG										
	BY AA	8	1.012	0.057						
	BY GC	8	1.005	0.072						
	MEAN BIAS	8	0.007	0.028						
KOOL 100, PHILLIPINES										
	BY AA	5	1.626	0.160						
	BY GC	5	1.472	0.218						
	MEAN BIAS	5	0.154	0.145						
KO... MACON										
	BY AA	10	1.264	0.103	10	0.747	0.067	10	37.140	1.579
	BY GC	7	1.167	0.078	10	0.621	0.072	7	33.440	2.202
	MEAN BIAS	7	0.070*	0.031	10	0.126*	0.020	7	3.191	1.088
KSL - 3										
	BY AA	410	0.547	0.075	301	0.642	0.056	300	53.812	2.991
	BY GC	395	0.548	0.083	283	0.579	0.071	272	51.593	4.488
	MEAN BIAS	395	-0.002	0.066	283	0.065*	0.063	272	2.246	3.757
L&M KS										
	BY AA	16	1.046	0.111	15	0.581	0.054	15	35.551	2.112
	BY GC	15	1.022	0.122	15	0.475	0.052	15	31.815	2.658
	MEAN BIAS	15	0.034	0.102	15	0.106*	0.049	15	3.736	1.372
L&M LIGHTS KS										
	BY AA	20	0.908	0.123	16	0.794	0.057	16	46.975	3.806
	BY GC	20	0.895	0.150	16	0.716	0.083	16	44.765	3.829
	MEAN BIAS	20	0.013	0.043	16	0.078*	0.062	16	2.210	2.034
LARK MILDS										
	BY AA	8	0.856	0.057						
	BY GC	8	0.840	0.067	8	0.160	0.019	8	15.997	1.377
	MEAN BIAS	8	0.016	0.029						
LUCKY STRIKE 80, PETERSBURG										
	BY AA	5	1.318	0.112						
	BY GC	5	1.298	0.071						
	MEAN BIAS	5	0.020	0.062						
LUCKY STRIKE, RED STRIPE, PET.										
	BY AA	24	1.166	0.071	19	0.741	0.067	19	38.969	1.554
	BY GC	24	1.110	0.080	16	0.633	0.042	16	37.052	1.942

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

BRAND DESCRIPTION		PAD ANALYSIS			FILTER ANALYSIS					
NRI		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
	MEAN BIAS	24	0.055*	0.076	16	0.117*	0.060	16	2.375	1.388
MARLBORO BOX										
	BY AA	16	1.132	0.056	16	0.779	0.057	16	40.738	1.769
	BY GC	16	1.099	0.054	16	0.726	0.071	16	39.745	2.889
	MEAN BIAS	16	0.033*	0.025	16	0.053*	0.065	16	0.993	2.133
MARLBORO KS										
	BY AA	8	1.264	0.161	8	0.911	0.065	8	42.017	2.243
	BY GC				5	0.784	0.064			
	MEAN BIAS				5	0.158*	0.033			
MARLBORO LIGHTS KS, HONG KONG										
	BY AA	8	1.280	0.101	8	0.961	0.113	8	42.859	4.519
	BY GC	8	1.129	0.206	8	0.775	0.094	8	41.146	8.333
	MEAN BIAS	8	0.151*	0.125	8	0.186*	0.023	8	1.713	3.989
MARLBORO LIGHTS BO, SAUDI ARABIA										
	BY AA	8	0.742	0.084	8	0.852	0.052	8	53.531	2.606
	BY GC	8	0.714	0.077	8	0.764	0.052	8	51.764	2.719
	MEAN BIAS	8	0.029*	0.033	8	0.089*	0.016	8	1.768	0.962
MARLBORO BO ISRAEL										
	BY AA	8	1.196	0.080	8	0.880	0.043	8	42.415	1.735
	BY GC	8	1.119	0.072	5	0.742	0.048	5	39.999	1.324
	MEAN BIAS	8	0.078*	0.047	5	0.146*	0.009	5	2.324	0.855
MERIT KS										
	BY AA	16	0.641	0.061	16	0.858	0.089	16	57.228	1.765
	BY GC	16	0.601	0.065	16	0.816	0.067	16	57.598	2.305
	MEAN BIAS	16	0.039*	0.022	16	0.042*	0.062	16	-0.370	2.310
MERIT KS, HONG KONG										
	BY AA	6	0.632	0.037	6	0.828	0.049	6	56.733	0.919
	BY GC	6	0.545	0.048	6	0.697	0.055	6	56.126	0.942
	MEAN BIAS	6	0.087*	0.033	6	0.132*	0.027	6	0.607	1.451
MERIT ULTRA KS										
	BY AA	16	0.332	0.026	14	0.634	0.054	14	65.285	1.382
	BY GC	16	0.320	0.031	14	0.571	0.060	14	64.377	1.901
	MEAN BIAS	16	0.012	0.038	14	0.062*	0.041	14	0.908	1.656
MERIT BO, SAUDI ARABIA										
	BY AA	8	0.776	0.042	8	0.699	0.028	8	47.389	1.037
	BY GC	8	0.744	0.046	8	0.622	0.024	8	45.589	1.027
	MEAN BIAS	8	0.033*	0.029	8	0.076*	0.026	8	1.800	0.650
MILD SEVEN										
	BY AA	8	1.247	0.085	7	0.436	0.188	7	25.049	9.247
	BY GC	8	1.190	0.074	8	0.326	0.149	8	20.806	7.943
	MEAN BIAS	8	0.057*	0.040	7	0.086*	0.078	7	3.114	2.827
MILL 2 VENT										
	BY AA	8	0.829	0.022						
	BY GC	8	0.821	0.020						
	MEAN BIAS	8	0.007	0.017						
NEWPORT KS										
	BY AA	24	1.293	0.100	16	0.727	0.058	16	36.465	1.359
	BY GC	24	1.217	0.072	16	0.613	0.049	16	33.571	1.524
	MEAN BIAS	24	0.077*	0.079	16	0.114*	0.063	16	2.894	1.548
NEWPORT LIGHTS KS										
	BY AA	8	0.749	0.084						
	BY GC	8	0.700	0.096						
	MEAN BIAS	8	0.049*	0.024						

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

BI DESCRIPTION / HRE		PAD ANALYSIS NUMBER OF RESULTS	PAD ANALYSIS MEAN RESULT	PAD ANALYSIS STANDARD DEVIATION	FILTER ANALYSIS NUMBER OF RESULTS	FILTER ANALYSIS MEAN RESULT	FILTER ANALYSIS STANDARD DEVIATION		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
NEWPORT BD, FINLAND											
	BY AA	8	1.346	0.035	8	0.711	0.037		8	38.277	1.002
	BY GC	8	1.057	0.039	8	0.587	0.047		8	35.678	1.593
	MEAN BIAS	8	0.089*	0.017	8	0.124*	0.028		8	2.600	0.874
NOW KS											
	BY AA	13	0.181	0.035	15	0.368	0.030		12	67.245	3.343
	BY GC	16	0.151	0.033	15	0.357	0.033		15	70.941	4.234
	MEAN BIAS	13	0.037*	0.032	15	0.011	0.023		12	-4.598	4.081
NOW 100											
	BY AA	16	0.236	0.060	13	0.355	0.034		12	60.385	4.451
	BY GC	14	0.223	0.053	13	0.375	0.022		10	62.500	3.004
	MEAN BIAS	14	0.007	0.019	13	-0.019*	0.026		10	-0.882	2.246
PALL MALL EXT LT											
	BY AA	8	0.729	0.042	8	0.749	0.025		8	50.700	1.766
	BY GC	8	0.701	0.041	8	0.660	0.030		8	48.500	1.475
	MEAN BIAS	8	0.027*	0.027	8	0.089*	0.021		8	2.200	0.876
PALL MALL EXTRA LIGHTS KS											
	BY AA	10	0.631	0.055	8	0.746	0.067		8	54.386	1.675
	BY GC	10	0.561	0.038	8	0.622	0.065		8	52.584	1.924
	MEAN BIAS	10	0.070*	0.046	8	0.124*	0.053		8	1.803	1.829
RALEIGH LIGHTS, PETERSBURG											
	BY AA	25	0.767	0.097	22	0.766	0.074		22	50.122	2.150
	BY GC	25	0.722	0.095	22	0.685	0.073		22	48.927	2.648
	MEAN BIAS	25	0.045*	0.036	22	0.080*	0.049		22	1.206	1.802
F GH LONG LIGHTS, PETERSBURG											
	BY AA	14	0.736	0.119	8	0.764	0.031		8	50.451	0.345
	BY GC	14	0.696	0.110	8	0.699	0.029		8	50.452	1.837
	MEAN BIAS	14	0.040*	0.040	8	0.065*	0.035		8	-0.001	1.805
RALEIGH PLAIN, LOUISVILLE											
	BY AA	15	1.429	0.077							
	BY GC	12	1.324	0.122							
	MEAN BIAS	12	0.118*	0.087							
RALEIGH 100, PETERSBURG											
	BY AA	11	1.212	0.110	9	0.787	0.082		9	39.192	0.922
	BY GC	11	1.130	0.083	9	0.629	0.045		9	35.963	1.495
	MEAN BIAS	11	0.082*	0.080	9	0.158*	0.053		9	3.229	1.413
RALEIGH, PETERSBURG											
	BY AA	11	1.055	0.078	9	0.686	0.055		9	39.532	1.360
	BY GC	11	0.975	0.049	9	0.547	0.039		9	36.122	2.111
	MEAN BIAS	11	0.079*	0.069	9	0.139*	0.053		9	3.410	2.107
SALEM KS											
	BY AA	21	1.115	0.094	15	0.723	0.061		15	39.271	1.461
	BY GC	21	1.065	0.121	15	0.572	0.067		15	34.972	2.892
	MEAN BIAS	21	0.050*	0.091	15	0.151*	0.050		15	4.299	2.332
SALEM LIGHTS KS											
	BY AA	16	0.636	0.059	16	0.684	0.051		16	51.878	2.018
	BY GC	16	0.611	0.045	16	0.618	0.037		16	50.300	1.972
	MEAN BIAS	16	0.024	0.063	16	0.066*	0.032		16	1.579	1.935
TAREYTON KS											
	BY AA	22	1.035	0.059	12	0.186	0.022		12	15.011	1.320
	BY GC	22	1.030	0.125	18	0.151	0.016		18	13.072	1.472
	MEAN BIAS	22	0.005	0.103	10	0.038*	0.015		10	2.533	1.325

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

9

BRAND DESCRIPTION		PAD ANALYSIS			FILTER ANALYSIS					
		NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
TIME 80, ISRAEL										
	BY AA	8	1.160	0.037	8	0.660	0.031	8	36.263	1.426
	BY GC	8	1.039	0.045	6	0.5020	0.038	6	32.636	1.883
	MEAN BIAS	8	0.121*	0.044	6	0.160*	0.028	6	3.480	0.693
TRIUMPH KS										
	BY AA	8	0.292	0.033	8	0.577	0.035	8	66.448	1.958
	BY GC	8	0.291	0.026	8	0.5950	0.030	8	67.172	1.707
	MEAN BIAS	8	0.001	0.022	8	-0.017	0.036	8	-0.724	1.697
TRUE KS										
	BY AA	14	0.459	0.039	12	0.472	0.031	12	51.273	1.816
	BY GC	14	0.454	0.037	12	0.4370	0.046	12	49.413	2.264
	MEAN BIAS	14	0.006	0.026	12	0.036*	0.028	12	1.859	1.854
TRUE KS, PETERSBURG										
	BY AA	21	0.585	0.050	19	0.588	0.038	19	50.575	2.377
	BY GC	21	0.610	0.079	16	0.5810	0.065	16	50.123	2.372
	MEAN BIAS	21	-0.026*	0.054	16	0.009	0.058	16	0.951	1.206
TRUE 100										
	BY AA	8	0.559	0.039	8	0.547	0.029	8	50.414	1.412
	BY GC	8	0.574	0.036	8	0.5320	0.024	8	48.159	1.698
	MEAN BIAS	8	-0.015	0.024	8	0.035*	0.035	8	2.255	1.038
VANTAGE KS										
	BY AA	34	0.692	0.048	26	0.597	0.045	26	56.725	2.048
	BY GC	29	0.679	0.055	26	0.5480	0.109	21	55.323	2.440
	MEAN BIAS	29	0.020*	0.039	26	0.049*	0.110	21	1.452	1.653
VANTAGE MENTHOL KS										
	BY AA	10	0.680	0.039						
	BY GC	10	0.688	0.105						
	MEAN BIAS	10	-0.008	0.088						
VICEROY KS, GUATEMALA										
	BY AA	6	0.860	0.069	6	0.442	0.028	6	33.969	1.800
	BY GC	6	0.733	0.085	6	0.2970	0.033	6	28.836	1.951
	MEAN BIAS	6	0.127*	0.027	6	0.145*	0.008	6	5.133	0.274
VICEROY KS, HAITI										
	BY AA	6	1.038	0.066	6	0.625	0.045	6	37.568	1.183
	BY GC	6	0.902	0.053	6	0.4330	0.047	6	32.417	2.340
	MEAN BIAS	6	0.137*	0.074	6	0.192*	0.084	6	5.151	2.142
VICEROY KS, PANIMA										
	BY AA	8	1.250	0.077	8	0.685	0.084	8	35.347	3.191
	BY GC	8	1.209	0.069	8	0.5340	0.027	8	30.650	1.190
	MEAN BIAS	8	0.041*	0.034	8	0.151*	0.067	8	4.697	2.569
VICEROY LIGHTS, PETERSBURG										
	BY AA	8	0.599	0.075	8	0.587	0.058	8	49.583	1.856
	BY GC	8	0.607	0.083	8	0.5300	0.027	8	46.763	2.843
	MEAN BIAS	8	-0.009	0.045	8	0.058*	0.036	8	2.820	2.402
VICEROY LONG LIGHTS, PETERSBURG										
	BY AA	8	0.654	0.039	8	0.699	0.049	8	51.648	1.487
	BY GC	8	0.655	0.051	8	0.5970	0.051	8	47.694	2.720
	MEAN BIAS	8	-0.001	0.036	8	0.101*	0.026	8	3.953	2.334
VICEROY RICH LIGHTS 100, PETERSBURG										
	BY AA	30	0.801	0.155	30	0.755	0.110	30	48.745	4.478
	BY GC	30	0.787	0.144	30	0.6980	0.110	30	47.144	4.630
	MEAN BIAS	30	0.014	0.055	30	0.057*	0.045	30	1.601	1.731

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BROWN AND WILLIAMSON TOBACCO CORPORATION

NICOTINE BIAS AND PRECISION FOR INDIVIDUAL BRANDS

10

B. DESCRIPTION	PAD ANALYSIS			FILTER ANALYSIS					
	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION	NUMBER OF RESULTS	MEAN RESULT	STANDARD DEVIATION
VICEROY RICH LIGHTS, JAPAN									
BY AA	37	1.011	0.085	21	0.250	0.017	21	20.166	1.628
BY GC	36	0.974	0.090	21	0.227	0.022	20	19.235	2.149
MEAN BIAS	36	0.038*	0.056	21	0.024*	0.018	20	0.897	1.094
VICEROY RICH LIGHTS, PETERSBURG									
BY AA	16	0.685	0.090	13	0.710	0.067	13	50.710	2.073
BY GC	16	0.678	0.095	13	0.435	0.058	13	48.377	3.232
MEAN BIAS	16	0.007	0.051	13	0.075*	0.048	13	2.333	1.692
VICEROY 100, LOUISVILLE									
BY AA	16	1.152	0.112	15	0.757	0.082	13	39.531	2.014
BY GC	16	1.083	0.102	15	0.610	0.080	13	35.837	2.448
MEAN BIAS	16	0.069*	0.049	15	0.147*	0.037	13	3.694	0.871
VICEROY 100, PETERSBURG									
BY AA	10	1.114	0.104	5	0.688	0.064	5	38.805	0.983
BY GC	10	1.085	0.112	5	0.570	0.034	5	36.044	1.155
MEAN BIAS	10	0.029	0.076	5	0.118*	0.038	5	2.761	0.655
VICEROY 70, GUATEMALA									
BY AA	8	1.035	0.092	8	0.362	0.026	8	25.978	1.295
BY GC	8	0.855	0.102	8	0.232	0.028	8	21.405	1.465
MEAN BIAS	8	0.180*	0.024	8	0.130*	0.009	8	4.573	0.612
VICEROY, PETERSBURG									
BY AA	19	1.131	0.128	12	0.675	0.073	12	38.468	2.853
BY GC	19	1.076	0.134	12	0.571	0.053	12	35.831	2.995
MEAN BIAS	19	0.055*	0.045	12	0.104*	0.026	12	2.637	0.894
WINSTON KS									
BY AA	16	1.026	0.140	13	0.825	0.162	13	44.056	2.506
BY GC	16	0.943	0.133	13	0.685	0.146	13	41.708	2.697
MEAN BIAS	16	0.083*	0.069	13	0.140*	0.055	13	2.348	1.538
WINSTON KS, HONG KONG									
BY AA	8	1.425	0.086	8	0.839	0.145	8	36.810	4.268
BY GC	8	1.327	0.093	8	0.635	0.124	8	32.075	4.172
MEAN BIAS	8	0.098*	0.034	8	0.204*	0.026	8	4.736	0.670
WINSTON LIGHTS KS, HONG KONG									
BY AA	6	0.862	0.026	6	0.755	0.031	6	46.694	0.747
BY GC	6	0.777	0.046	6	0.600	0.044	6	43.565	0.829
MEAN BIAS	6	0.085*	0.030	6	0.155*	0.038	6	3.129	0.925
WINSTON LIGHTS BD, SAUDI ARABIA									
BY AA	8	0.891	0.059	8	0.864	0.037	8	49.244	1.358
BY GC	8	0.836	0.041	8	0.716	0.059	8	46.093	2.143
MEAN BIAS	8	0.055*	0.054	8	0.147*	0.049	8	3.151	1.140
WINSTON ULTRA LIGHT KS									
BY AA	8	0.427	0.079	5	0.570	0.023	5	57.104	4.261
BY GC	8	0.425	0.072	5	0.530	0.069	5	55.434	5.548
MEAN BIAS	8	0.003	0.014	5	0.040	0.061	5	1.669	3.386
WINSTON 100									
BY AA	16	1.091	0.066	16	0.793	0.038	16	42.109	1.308
BY GC	16	1.045	0.060	16	0.681	0.080	16	39.390	3.260
MEAN BIAS	16	0.046*	0.049	16	0.112*	0.065	16	2.719	2.954

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APPENDIX V

STANDARD TESTING PROCEDURE

ANALYTICAL METHODS PERFORMANCE CONTROL PROGRAM

Authors: Mr. J. P. Markham
Mr. W. O. Crain

Procedure C-21

Part I

Part II

January, 1980

2023100226

Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

STANDARD TESTING PROCEDURE

Title

Analytical Methods Performance Control Program

Purpose

The purpose is the establishment of a standard procedure to be used by each B&W laboratory for the continuous monitoring and controlling of various analytical methods performances.

Method Outline

A uniform batch of samples will be prepared and distributed to each laboratory. The individual laboratories will perform preliminary tests and use the data obtained to establish control limits and sampling schemes. Test results are then charted, and decisions are made as to whether the method is operating in control.

Procedures Included

Part I

Test Number	Description
C-3 and/or C-15	Menthol Content of Cigarette & Tobacco
C-5	Percent Ventilation, Cigarette
C-8	Glycerine & Propylene Glycol Content of Tobacco
C-11	Cigarette Ends Stability
C-14	Cigarette Firmness
C-16	Coal Retention of Cigarettes

Part II

Test Number	Description
C-1	Tobacco Moisture Content

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APPLICABLE METHODS:

Test Number	Description
C-3 and/or C-15	Menthol Content of Cigarette & Tobacco
C-5	Percent Ventilation
C-8	Glycerin & Propylene Glycol Content of Tobacco
C-11	Cigarette Ends Stability
C-14	Cigarette Firmness
C-16	Coal Retention of Cigarettes

In addition, pressure drop, circumference and moisture content are included.

SECTION 1 - SAMPLE PREPARATION:

Control of process variation is extremely critical in preparation of the Control cigarette. This sample is used to monitor method performance. Excessive product variation will result in large control limits or unreasonably large sample sizes to achieve desired detection levels. General guidelines are provided below.

1. Select a mentholated brand with the following restrictions:

   a. 70% $\leq$ coal retention $\leq$ 90%

   b. Ends stability $\leq$ 10 mg

   c. Porous plug wrap and perforated tipping

2. The Development Center will fabricate eighteen (18) cases of cross-check samples in Item 1 above. This should provide about a six (6) month supply for all labs. The sample must be of homogenous materials covering the general range of values expected to normally be encountered for the test methods; e.g., prepare the sample from one operation of tobacco.

3. R&D will perform an initial analysis to determine the suitability of the samples as a control. General guidelines are provided in Table I. The standard deviation ($\hat{\sigma}$) should not exceed 1.45 times the guidelines. If several, say two or three, standard deviations exceed the guidelines, consider remaking the sample. The ultimate criterion, however, is an economic one. The increase in analysis costs must be compared to the costs of remaking the control.

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4. Randomize cartons among cases and then randomize packs among cartons within a case.

5. If the sample is acceptable as a control, overwrap the cartons and cases.

6. Store in an area where the temperature never exceeds 80°F.

SECTION 2 - PRELIMINARY SURVEY:

The preliminary survey is to be done at each of the participating labs. The purpose of the preliminary survey is to determine the reference line for control charts. Further, these data are used to estimate sampling requirements for control of the standard test procedures (STP).

A. Sample Selections:

1. Randomly select eleven (11) cartons from the sample above (see Table II for sampling scheme).

2. Cigarette Weight: Determine the gross weight of twenty (20) groups of 50 cigarettes each.*

3. Ends Stability: Determine ends stability for the cigarette weight groups.

4. Humectants and Menthol: Randomly select 2 groups of 40 cigarettes for humectant and menthol analyses. This provides twenty (20) determinations each of humectant content and menthol content.

   Precaution: Seal the 2 groups of 40 cigarettes in 1 oz. vials with 2 cigarettes per vial to minimize menthol and humectants losses.

5. Circumferences: Randomly select 50 cigarettes and determine circumference.

6. Coal Retention: Randomly select 10 groups of 30 cigarettes for coal retention.

7. Firmness: Randomly sample 10 groups of 50 cigarettes from Item 1 above and divide each group into two (2) groups of 25 cigarettes for firmness.

8. Moisture: Immediately after the firmness tests are finished, rip each group of 25 cigarettes for moisture testing.

*Gross weight is not a controlled specification, it is listed because a change in gross weight can be an indication the control cigarettes have undergone a change.

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9. Ventilation Rate: Randomly sample 75 cigarettes for ventilation rate.

10. Pressure Drop: Randomly sample 100 cigarettes for pressure drop.

B. Test Details:

1. All testing must be divided among the qual three or who routinely perform these tests. They s e average across shifts and, a minimum of 3 to 5 day

2. When multiple units of equipment are used atory, the laboratory, the tests must be equally spli 1 equipment. on all units.

3. Calibrate all equipment before conducting

C. Calculations:

1. Calculate averages, standard deviations ($\hat{\sigma}$) and RSD (relative standard deviation) for Items 2 - 10 in Subsection A, above.

Definition: $$RSD = \frac{\hat{\sigma}}{\bar{x}} \times 100\%$$

Caution: The standard deviation of coal retention is calculated using the following:

$$\hat{\sigma} = \sqrt{\frac{CR\ (100-CR)}{N}}$$

Where CR = coal retention (%) and N = the number of cigarettes tested.

Example: $$\hat{\sigma} = \sqrt{\frac{(80\%)\ (20\%)}{300}} = 2.31\%$$

D. Sample Size (Daily) Estimation:

The sample size for a control varies from two (2) to ten (10) test units for each of these STP.

1. Sample sizes (n) for C-3, C-5, C-8, C-11 and C-14 can be estimated using the equation:

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$$n = \frac{(1.96)^2 \ (RSD)^2}{(E)^2}$$

where E is obtained from Column 1 in Table I and RSD is the observed RSD.

Note: Always round-up to the next whole number.

Example: $n = \frac{(1.96)^2 \ (6\%)^2}{(4\%)^2} = 9$

2. For C-16, use the equation:

$$n = \frac{4 \times CR \ (100 - CR)}{(E)^2}$$

where CR is the average coal retention (%) for the preliminary survey.

Note: Always round-up to the next multiple of 30.

Example: $n = \frac{4 \times (80\%) \ (20\%)}{(7\%)^2} = 131$ rounds up to 150

SECTION 3 - CONTROL CHARTING:

Each Branch must maintain $\bar{x}$ - charts and R - charts. These charts must be updated daily and applied to the daily averages.

A. The number of controls for each of the STP must be evenly dispersed amoung routine samples and across shifts. When multiple units of equipment or operators are used within a shift, divide the controls amoung the instruments and/or operators.

B. Construct $\bar{x}$ - charts and R - charts for each STP based on averages and standard deviations of test results from the preliminary survey. Select a convenient scale that covers approximately two-thirds of the graph. Examples of $\bar{x}$ - charts and R - charts are attached.

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1. STP C-3, C-5, C-8, C-11 and C-14

<u>$\bar{x}$ - chart</u>

Center line: $\bar{x}^*$

Control limits: $\bar{x} \pm 3 \frac{\hat{\sigma}^*}{\sqrt{n}}$

Where n = number of control analyses per day.

<u>R - chart</u>

Center line: $\bar{R} = d_2 \hat{\sigma}^*$

Upper Control Limit (UCL) = $D_4\bar{R}$

Lower Control Limit (LCL) = $D_3\bar{R}$

where d_2, D_4 and D_3 are obtained from Table III. The sample size, n, for d_2 is the number of daily replicates.

2. STP C-16

<u>$\bar{x}$ - chart</u>

Center line: $\overline{CR}$*

Control limits: $\overline{CR} \pm 3 \times \sqrt{\frac{\overline{CR}\ (100 - \overline{CR})}{N}}$

where N = the number of test units times 30.

<u>R - chart</u>

Center line: $\overline{CR}$

Control limits: $\overline{CR} \pm 3 \times \sqrt{\frac{\overline{CR}\ (100 - \overline{CR})}{30}}$

C. When the supply of the control sample is nearly exhausted, overlap the control charts for several weeks with the revised control charts for the replacement sample. This overlap also includes the time for the preliminary survey.

*Estimated from the preliminary survey.

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Source: https://www.industrydocuments.ucsf.edu/docs/jrkm0000

SECTION 4 - DECISION SCHEME:

When applying the charting methods above, employ the following criteria:

A. Operator Level

To control the method within-day, the operator examines individual results. If two or more successive controls exceed the 3-sigma limits ($3 \times \hat{\sigma}$), then find out why.

B. $\bar{X}$ - Charts

1. Compulsory

a. One or more daily average outside the control limits indicates lack of control. In such cases, stop the analysis and find out what went wrong.

b. If two or more successive daily averages are beyond two sigma ($2 \times \hat{\sigma}/\sqrt{n}$) limits, stop the analysis and find out what went wrong.

2. Caution:

a. If four or more successive daily averages are outside one sigma ($\hat{\sigma}/\sqrt{n}$) limits, then find out why.

b. If eight or more successive averages are above or below the center line, then find out why.

C. R - Charts

Individual values outside the control indicate a significant change in the variation of test results. If the pattern is persistent, say two or three successive days, then find out why.

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TABLE I

Guidelines for Control Cigarettes

Measurement	Error (E) RSD(%)	Standard Deviation $\bar{x}$
Circumference (mm)	1	0.15
Coal Retention (%)	7	5
Ends Stability (mg)	50	1.3
Firmness* (cts/25)	4	7
Propylene Glycol (%)	5	0.07
Glycerin (%)	5	0.07
Firmness Moisture (%)	2.5	0.3
Cigarette Pressure Drop (in.)	5	0.3
Menthol (%)	5	0.02
Cigarette Weight (mg)	1	10
Ventilation Rate (%)	30	3.5

*Moisture Corrected

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TABLE II

SAMPLING SCHEME FOR PRELIMINARY SURVEY

11 Cartons (110 packs)

Randomly select 2 cigarettes from each of 20 packs for menthol tests.

Randomly select 2 cigarettes from each of 20 packs for humectant analyses.

Randomly select 50 cigarettes for circumferences.

Randomly select 300 cigarettes for coal retention.

Randomly select 20 groups of 25 cigarettes for firmness. Determine moisture content on each group.

Randomly select 75 cigarettes for percent ventilation.

Randomly select 100 cigarettes for pressure drop.

Randomly select 20 groups of 50 cigarettes for gross weight (50 packs).

Run these 20 groups of 50 cigarettes for ends stability.

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EXAMPLE 1

$\bar{X}$ Chart

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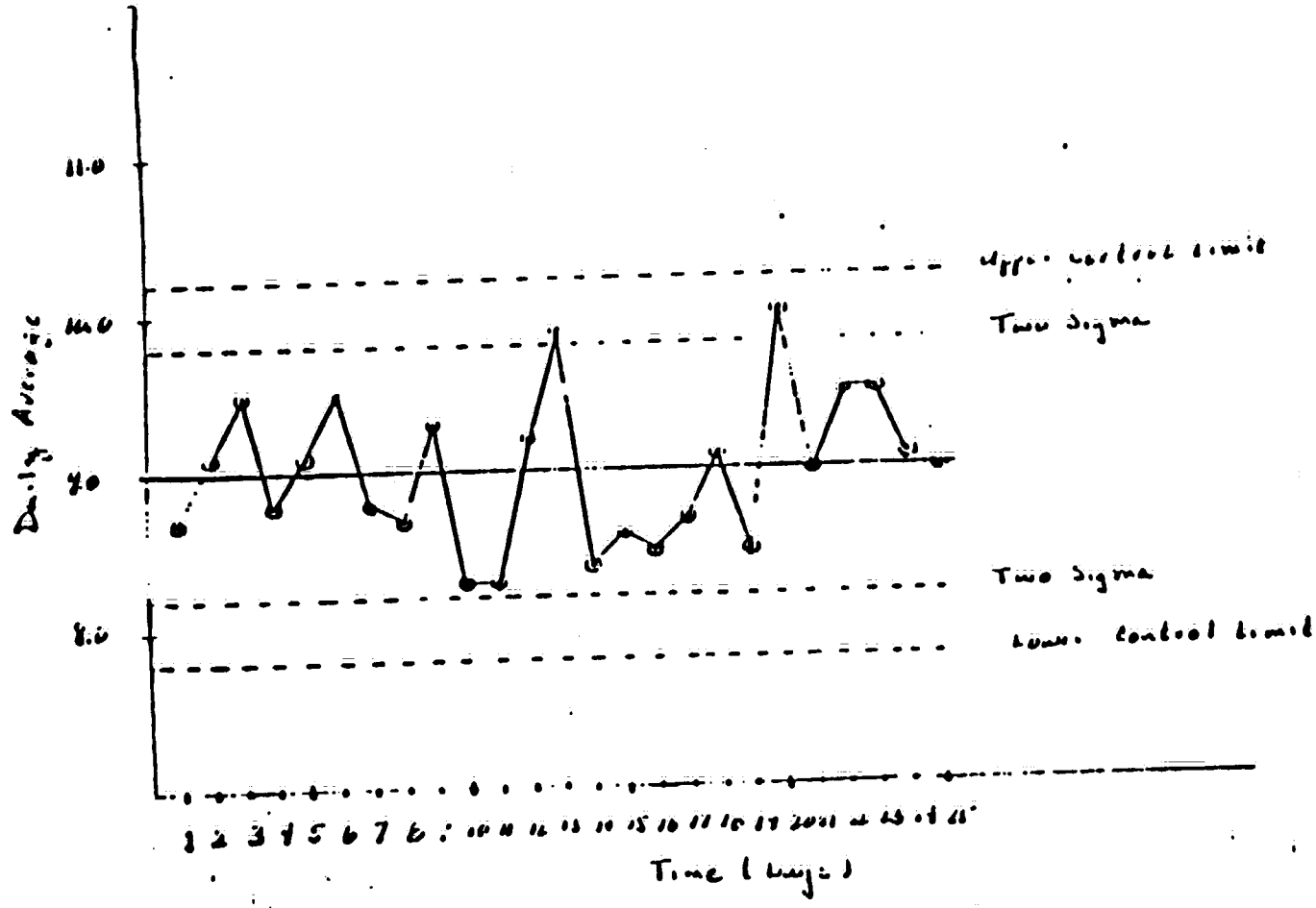
Center line* = 9.00

σ = 1.0 UCL = 10.2

n = 6 LCL = 7.8

*Preliminary Survey



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BROWN & WILLIAMSON TOBACCO CORPORATION

Research Department

Standard Method of Analysis

Method No.: SM-134 Date Issued: March 11, 1983

THE AUTOMATED DETERMINATION OF TAR, NICOTINE, AND CARBON MONOXIDE BY THE FTC METHOD

Mr. R. A. Burge

Distribution

Dr. J. H. Lauterbach

Mr. J. F. Nall

Mr. L. L. Shockley

Mr. M. S. Frank

Mr. R. A. Burge

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BROWN & WILLIAMSON TOBACCO CORPORATION

Research Department

Standard Method of Analysis

Method No.: SM-134 Date Issued: March 11, 1983

Method Class:

Title: The Automated Determination of Tar, Nicotine, and Carbon Monoxide by the FTC Method

Author: Mr. R. A. Burge

Summary: Cigarettes are smoked on a Phipps & Bird smoking machine. Carbon monoxide (CO) is collected and measured. Gelman pads are used to trap particulates and the total particulate matter (WTPM) is measured by weight. The Gelman pads and filter tips are placed into vials and extracted with isopropanol. Water and nicotine content of the pad extracts and the nicotine content of the filter extracts are determined. Tar is then calculated from these results. The method measures WTPM, water, nicotine, CO and puff number. Tar is calculated using WTPM, water and nicotine results. Nicotine Retention Efficiencies (%NRE) are calculated using nicotine results. Tar, nicotine, and CO are reported as mg/cig.

Sample Size: The sample consists of 80 cigarettes divided into 16 subsamples (ports) of five cigarettes each. Each of the subsamples is smoked onto a filter trap where the WTPM is collected and measured.

Range and/or Sensitivity: Tar can be measured precisely in samples delivering from 0.5 - 40.0 mg/cig. CO can be measured in samples delivering 0.5 - 25.0 mg/cig.

Precision: Method precision was estimated for tar from smoke determinations on two control samples (8.8 and 5.0 mg/cig). The standard deviations were 0.5 and 0.4 mg/cig, respectively. The relative standard deviations were 5.7 and 8.0%, respectively.

Analysis Time - Setup: (man-hours) - 8 hours (16 port sample)

- Take-down: (man-hours) - 2.0

- Variable: Approximately 20 ± 2 samples/day. (man-hours/sample) ≈4.0

Approved for issue: J. H. Lauterbach Date: 3/10/83

J F Nell Date: 3/10/83

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1. Principle of Method

Total particulate matter (WTPM) and puff number are measured by smoking cigarettes on a Phipps & Bird Mark I smoke machine (ref. 1). The WTPM is collected on a smoke trap that is used to collect aerosols. The trap (Gelman pad), which collects smoke particulates, is extracted with isopropanol containing two (2) internal standards. Nicotine and water are measured in this extract. Nicotine is determined using an AutoAnalyzer I system (ref. 2). Water is determined using gas chromatography (ref. 3). Filter tips are extracted with isopropanol, and the extract is analyzed for nicotine via an AutoAnalyzer I system (ref. 2).

Carbon monoxide is determined in the gas phase of cigarette smoke by nondispersive infrared (NDIR) analyzer. The gas phase of each port of smoke is collected in a bag and each bag is subsequently sampled when smoking is complete.

Tar and CO are calculated using a computer system. Results are reported as mg/cig.

2. Range and Sample Size

2.1 This method is used to determine tar, nicotine, WTPM, CO, % NRE, and puff number in whole smoke. A minimum of 20 cigarettes is recommended. Five cigarettes (one port) are smoked per Gelman pad (smoke trap). Two pads are combined and extracted with isopropanol. These extracts are used to measure nicotine and water which are used to calculate tar. % NRE is calculated from the nicotine extract results. CO is measured in the vapor phase. (Recommended minimum ports smoked = 4; normal = 16.)

2.2 Tar content is determined routinely from 0.5 - 40.0 mg/cig.

2.3 Nicotine content is measured routinely from 0.02 - 2.6 mg/cig using AutoAnalyzer Methodology. Higher concentrations are measured with appropriate dilutions. Nicotine levels as low as 0.001 mg/cig are measured via gas chromatography method (ref. 3).

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2.4 CO is measured routinely from 0.5 - 20.0 mg/cig. Higher concentrations can be measured, but modifications in the smoking apparatus are needed.

2.5 Water content is measured routinely from 0.2 - 4.0 mg/cig (0.1 - 2.0 mg/mL). Higher concentrations are measured with appropriate dilutions.

2.6 Puff number is automatically calculated by the computer using a pulse generator as a signal. Typical ranges for this result are from 6.0 - 15.0 puffs/cig. % NRE obtained from nicotine is also calculated by the computer. The typical range for % NRE is 25 - 80%.

3. Safety Precautions

3.1 Normal safety precautions are employed.

3.2 Nicotine is very poisonous. Standards containing pure nicotine should be handled with caution (ref. 2).

3.3 CO is a very poisonous gas, therefore CO cylinders must be stored in a hood. Calibration standards should be handled with caution.

4. Interferences and Corrective Measurements

4.1 Plain end cigarettes are taped so that leakage does not occur when these cigarettes are inserted into the dental dam (rubber membrane) on the front of the Gelman pad holder.

4.2 Charcoal filters cannot be analyzed for nicotine by the AutoAnalyzer method. Charcoal interferes with this method. GC analysis is used to determine nicotine concentration for these filters.

4.3 Appropriate measures to insure the correct computer response must be taken if less than five cigarettes are smoked per Gelman pad (see computer manual for necessary corrective steps).

CAUTION: CO measurements are not valid for less than five cigarettes/port, unless appropriate volume corrections are made.

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4.4 Special smoke delivery methods must be instituted if tar results are expected to be below 0.5 mg/cig (refs. 4, 5).

4.5 Care must be taken when smoking cigarettes that have ventilated tipping. The vent holes in the tipping must not be covered by the rubber membrane on the end of the smoke trap assembly.

4.6 For cigarettes with filters that have been pulled, the tipping on tobacco sections containing ventilation must be taped or blocked so that ventilation does not occur.

4.7 When tobacco sections of cigarettes are smoked, they must be taped with "Magic" tape so that leakage does not occur when these cigarettes are inserted into the dental dam (rubber membrane) on the front of the Gelman pad holder.

5. Precision

5.1 Tar deliveries of two control samples were collected at the rate of 6 ports/day for a ten day period.

5.2 The mean ($\bar{X}$), standard deviation (S.D.), and percent relative standard deviation (R.S.D.) of the tar deliveries for both referees were:

	Control 1	Control 2
$\bar{X}$	8.8 mg/cig	5.0 mg/cig
S.D.	0.5	0.4
R.S.D.	5.7%	8.0%
N	30	30

5.3 Nicotine deliveries of two referee samples (BCR-2 and VRL-1) were collected for 13 days. Each referee sample was run from 2 to 10 times each day.

5.4 The mean ($\bar{X}$), standard deviation (S.D.), and percent relative standard deviation (R.S.D.) of the nicotine deliveries for both referees were:

	BCR-2	VRL-1
$\bar{X}$	0.28 mg/cig	0.78 mg/cig
S.D.	0.04	0.05
R.S.D.	14%	6%
N	81	95

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5.5 CO deliveries of two control samples were collected at the rate of 8 ports/day for a ten day period.

5.6 The mean ($\bar{X}$), standard deviation (S.D.), and percent relative standard deviation (R.S.D.) of the CO deliveries for the two control samples were:

	Control 3	Control 4
$\bar{X}$	8.8 mg/cig	3.3 mg/cig
S.D.	0.76	0.33
R.S.D.	7.2%	10.0%
N	80	80

6. Apparatus

6.1 Phipps & Bird Mark I Smoking Machine, designed and licensed by Philip Morris Research Laboratories, with a 20 port capacity.

6.2 Gelman smoke analysis filters - plastic disposable type holders. This filter holder is leak proof and chemically inert. It meets or exceeds all I.S.O./D.I.S 3308.2 standards.

6.3 Filter discs made of a glass fiber material, 1 - 2 mm thick with a diameter of 47 mm. The rough filter surface faces the oncoming smoke. The filter material must have the following characteristics.

6.3.1 It must retain at least 99.9% of all particulates having a diameter equal to or greater than 0.3 μm of a dioctylphthalate aerosol at a linear air velocity of 140 mm/s (28 linear feet/minute (LF/min)).

6.3.2 The draw resistance of a filter assembly must not exceed 900Pa (9 mbar) at a flow of 17.5 cc/s.

6.3.3 The polyacrylate binder shall not exceed 5% (m/m).

6.4 Thin latex rubber membrane made from dental dam cut into square pieces approximately 3.5 x 3.5 cm. This square has a hole in the center made from a #1 hole punch.

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6.5 Silicone rubber "O" rings, small - 3/8" I.D.

6.6 Alnor Velometer Type 3002: Used to measure the machine airflow at each of the three tri-ducts. A jet probe, #3910, to measure the air velocity is connected to the Alnor Velometer. Each duct is set to pull between 350 and 500 LF/min air velocity.

6.7 Standard Electric Timer Model 600-100: Used to measure the puff duration to 1/100th of a second.

6.8 A 50 cc Buret or Soap Bubble Flow Meter: Used to measure the 35 cc puff volume for each of the 20 ports. It is graduated in 0.1 cc intervals.

6.9 Analytical Balance - Mettler Model HL-32: 160 g capacity, accurate to 0.1 mg.

6.10 Filtrona Model ATCOM 300 CK Carbon Monoxide NDIR Analyzer: Equipped with adapter unit for the Phipps & Bird Model Mark I smoking machine.

6.11 Computer Hardware

6.11.1 Hewlett-Packard 3070A Terminal

6.11.2 Hewlett-Packard 2240A Control Processor

6.11.3 Hewlett-Packard 1000 E Computer

6.12 Vertical Vester Shaker

6.13 Filamatic vial filler set at 20 cc delivery.

6.14 Thread - 325 yd spool of J. & P. Coats black, cotton covered, polyester dual duty sewing thread.

6.15 Butt Marker

6.16 Set of Class S NBS calibrated weights.

7. Chemicals

7.1 Hi-Vacuum Pump Oil

7.2 SNOOP

7.3 CO Standard Gas Mixtures supplied by AIRCO or Matheson.

7.3.1 6.0% CO, 94.0% high purity nitrogen.

7.3.2 2.0% CO, 98.0% high purity nitrogen.

7.3.3 4.0% CO, 96.0% high purity nitrogen.

CAUTION: These tanks should be stored in a well ventilated area such as a fume hood due to the poisonous nature of CO.

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8. Procedure

8.1 Sample Preparation - Place 30 to 60 randomized packs (600 - 1200 cigarettes) in a composite pool (normal sample size).

8.1.1 Randomly select 80 cigarettes from the composite sample pool and butt mark.

8.1.2 Normal butt markings are:

Filtered Cigarettes - tipping plus 3 mm.

Plain End Cigarettes - 23 mm.

8.1.3 Place a filter insertion mark on the filter tipping 11 mm from the end of the filter. This mark designates how far the filter end of the cigarette is inserted into the dental dam on the smoke trap holder (8 mm insertion into dental dam plus 3 mm for plastic lucite bar on Phipps & Bird smoke machine). Plain end cigarettes carry the same insertion mark.

8.1.4 Place the 80 cigarettes into a plastic Tupperware container, which is then capped, computer labeled, and delivered to the smoke laboratory.

8.1.5 Condition the cigarettes in the Tupperware container (uncapped) for at least 16 hours at 75 ± 2°F and 60 ± 2% R.H. Typical moisture level in the tobacco after conditioning is approximately 13.5%.

8.2 Smoking Machine Setup, Calibration, and Checkout

Check the smoke machine each day as follows:

8.2.1 Check the syringes for oil content. They should contain at least 2 cc of oil (Hi-Vacuum Pump Oil) to lubricate and leak seal the plungers. To add oil, unscrew the syringe by hand, remove plunger and add oil to the large open end of the syringe while keeping a finger over the small threaded end. Replace the plunger and reconnect the syringe, being careful not to break the metal tip off of the syringe when tightening.

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8.2.2 Turn the main power switch to ON. Turn the power switch on the console to ON (this powers the plug strip in the smoke machine). Set the normal/volume check switch to NORMAL. Set the clock switch to AUTOMATIC. Allow the machine to cycle at one minute intervals for 10 - 15 minutes. While the machine is cycling, measure the one minute time intervals with a stop watch. The time of each cycle should be one minute ±0.05 seconds.

8.2.3 Volume check two different reference ports each morning (e.g. - a combination of ports such as 1&11, 2&12, 3&13, ... 10&20). After completion of the smoke schedule for the day, volume check all ports and reset to a 35 ±0.3 cc volume if necessary. Volume checking of each port is accomplished as follows: using an inverted 50 cc buret and SNOOP, draw the solution up to the 40 cc mark to lubricate the inner surface of the buret. Turn the normal/volume check switch to VOLUME CHECK and the clock switch to MANUAL. Using a single bubble, adjust to approximately 0.5 cc on the buret and insert the tube from the buret into the port receiver. Press the manual trip switch on the cord extending from the Filamatic unit in the base of the smoking machine. Subtract the original bubble reading from the final reading obtained after pressing the switch on the cord. The volume measurement for each port should be 35 ± 0.3 cc. Make necessary adjustments to any port that is outside these limits. This is accomplished by loosening the set screw on the eccentric cam located next to the base of the syringe on the lower cam shaft. Move the cam up or down as required and lock the set screw. Measure the puff volume again as above.

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8.2.4 The standard puff duration is 2.0 ± 0.05 seconds for an individual puff. Use a standard automatic timing device to measure puff duration. This device plugs into the timing circuit located on the upper right hand corner of the smoke machine cabinet.

8.2.5 Check the puff counters to see that ten units (10.0) are registered with each puff; if necessary, adjust the pulse generator located in the rear of the puff counter cabinet so that each counter registers 10.0 count units.

8.2.6 Turn the normal/volume switch to NORMAL.

8.2.7 Check the air velocity in the tri-duct hood system using the ALNOR velometer and test probe. Each tri-duct should be set at 400 ± 50 LF/min.

8.2.8 Adjust the velocity to 400 LF/min at each duct. After adjusting each duct, by using the vane above the duct hole, read the velocity again to insure the proper air flow across all smoking machines.

8.3 Preparation of Smoke Assembly Traps.

8.3.1 Use preassembled Gelman disposable filters.

8.3.2 Leak test the assembly before use by subjecting it to a vacuum equivalent to 9.0 inches of water. Discard all assemblies that do not hold this vacuum.

8.3.3 Fasten a piece of dental dam, 35 mm x 35 mm square with a 4-6 mm diameter hole in the center (cut with a #1 hole punch), to the front of the Gelman holder with an "O" ring. Care is taken to assure that the hole is centered and not stretched out of proportion.

8.3.4 Place the assembly into its proper position in the smoke machine tray (ten per tray).

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